Biyani's Think Tank

***Concept based notes***

# Biochemistry-I

***(B.Sc. Biotechnology Part-I)***

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# Preface

I am glad to present this book, especially designed to serve the needs of the students. The book has been written keeping in mind the general weakness in understanding the fundamental concepts of the topics. The book is self-explanatory and adopts the “Teach Yourself” style. It is based on question-answer pattern. The language of book is quite easy and understandable based on scientific approach.

Any further improvement in the contents of the book by making corrections, omission and inclusion is keen to be achieved based on suggestions from the readers for which the author shall be obliged.

I acknowledge special thanks to Mr. Rajeev Biyani, *Chairman* & Dr. Sanjay Biyani, *Director* (*Acad.*) Biyani Group of Colleges, who are the backbones and main concept provider and also have been constant source of motivation throughout this Endeavour. They played an active role in coordinating the various stages of this Endeavour and spearheaded the publishing work.

I look forward to receiving valuable suggestions from professors of various educational institutions, other faculty members and students for improvement of the quality of the book. The reader may feel free to send in their comments and suggestions to the under mentioned address.

**Author**

# Syllabus

## B.Sc. Part-I

## Biochemistry-I

***Note :*** *Question No. 1 shall consist of questions requiring short answers and shall cover entire paper. The paper is divided to four sections. Students are required to attempt five questions in all selecting not more than one question from each section. All questions carry equal marks.*

**Section-A**

**1. Concept of life and living processes :** The identifying characteristics of a living matter.

**2. Cell membrane System and Cell wall :** Cell Membrane and its Organization; Elementary idea of cellular constituents : Nucleus, Mitochondria, Golgi bodies, Endoplasmic reticulum, Lysosomes and Micrabodies; Bacterial and Plant Cell walls.

**Section-B**

**1. Important properties of water,** the law of mass action association of water and its ionic product, pH, Bronsted acids, ionization of weak acids and Henderson Haeselbate uation, Titration Curves, buffering action and physiologic offers.

**2. Biomolecules :** The small molecules of life–Sugars, Organ acids, amino acids and nucleotides Macromolecules of life polysaccharides, fats, proteins and nucleic acids, General idea of primary, secondary, tertiary and quaternary structure.

**Section-C**

**1. Nucleus and Heredity:** Nuclear mernbrane; Nucleolus, Nuclear pores; Chromosomes; Packaging of DNA, DNA is Genetic material; DNA replication-basic concept : From DNA to RNA: Ribosomes and protein synthesis.

**2. Mitochondria and Release of Energy:** Structure of organization and function; Elementary account of Glycolysis and Krebs cycle and role of mitochondria in the later process.

**Section-D**

**1. Chloroplasts:** Capturing energy from the sun: Structure organization and function; Basic information on 'light' and 'dark' reactions of photopsynthesis and participation chloroplast in the process in $C_3$ + $C_4$ and CAM plants.

**2. Enzymes:** Nomenclature and classification, co-enzymes and co-factors, reaction and derivation of Michaelis-Menten equation kinetics and allosteric regulation of enzymes, isozymes; more of catalysis.

**3. Vitamins:** Their structure, properties and Biological structures.

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# Content



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# Section-A

## Chapter-1

# Concept of Life & Living Processes

**Q.1 Characteristics of living organisms include**

A) the ability to adapt to the environment.
B) the ability to evolve over time.
C) possessing homeostatic mechanisms.
D) the ability to reproduce
E) All of the choices pertain to living organisms

**Ans.: (E) All of the choices pertain to living organisms**

**Q.2 Which of the following sequences of organization is likely to be seen in a multicellular organism, going from smallest to largest?**

A) cell, organ, tissue, organism
B) cell, organ, system, tissue
C) cell, tissue, system, organism
D) organism, system, organ, tissue
E) tissue, system, cell, organ

**Ans.: (C) cell, tissue, system, organism**

**Q.3 Which of the following characteristics is NOT required for the life of an individual organism to continue?**

A) to be organized
B) to respond
C) to metabolize
D) to reproduce
E) to acquire energy

**Ans.: (D) to reproduce**

**Q.4 Which statement is FALSE about nearly all living things?**

A) Living things are made up of cells.
B) Living things must obey the laws of chemistry and physics.
C) Living things show biological organization and other common characteristics of life.
D) Emergent properties can be used to distinguish living things from nonliving things.
E) Living things are composed only of organic elements, whereas nonliving things are made up of inorganic elements.

Ans.: (E) Living things are composed only of organic elements, whereas nonliving things are made up of inorganic elements.

**Q.5 Which of these is the process by which changes occur in the characteristics of species of organisms over time?**

A) evolution
B) metabolism
C) adaptation
D) homeostasis
E) photosynthesis

**Ans.: (A) evolution**

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**Q.1 What are the identifying characteristics of Living matter?**

**Ans.:** (i) Living organisms are highly complicated and organized structures and contain large number of different organic molecules.

(ii) Each component unit of a living object appears to have specific purpose or function.

(iii) The living organism have ability to extract, transform and use energy from their environment either in form of organic nutrients or radiant energy of sunlight.

(iv) The most remarkable attribute of living organism is their capacity for self replication.

**Q.2 Write axioms or principles of Living State.**

**Ans.:** (i) There is basic simplicity in structure of biological molecules.

(ii) Living organisms use same kind of building block molecules and appear to have common ancestry.

(iii) Identities of each species or organism are preserved by its possession of distinctive sets of nucleic acid and proteins.

(iv) All biomolecules have specific functions in cells.

(v) Living organisms create and maintain their complex, orderly, purposeful structures at the expense of free energy.

(vi) Living cells are self-regulating chemical engines.

(vii) It maintains itself in dynamic steady state far from equilibrium with its surrounding.

(viii) Genetic information is encoded in units that are submolecular in dimensions.

(ix) It carries out various reactions catalyzed by biocatalyst or enzymes.

(x) The energy needed is provided directly or indirectly by solar energy.

□ □ □

# Chapter-2

# Cell Membrane System & Cell Wall

**Q.1 Cell organelles are embedded in**

A) Nucleolus

B) Cytoplasm

C) Protoplasm

D) Mitochondria

**Ans.: B) Cytoplasm**

**Q.2 Which of the following correctly matches an organelle with its function?**

A. mitochondrion . . . photosynthesis
B. B)nucleus . . . cellular respiration
C. ribosome . . . manufacture of lipids
D. lysosome . . . movement
E. central vacuole . . . storage

**Ans. (e) central vacuole . . . storage**

**Q.3 Which one of the following is not a constituent of cell membrane?**

A. Phospholipid
B. Glycolipids
C. Cholesterol
D. Proline

**Ans.: (D) Proline**

**Q.4 Plasma membrane is made up of**

A. Protein, Lipids, Carbohydrates
B. Protein, lipids
C. Protein
D. Protein, Cabohydrates

**Ans.: A) Protein, Lipids, Carbohydrates**

**Q.5** Which of the following are all present in animal cells

A. mitochondria, cell membrane, cell wall, cytoplasm
B. chloroplasts, cytoplasm, vacuole, nucleus
C. nucleus, cell membrane, mitochondria, cytoplasm

D. vacuole, cell membrane, nucleus, mitochondria

**Ans.: (C) nucleus, cell membrane, mitochondria, cytoplasm**

**Q.6** What cell organelle is responsible for the production of ATP?

A. chloroplast
B. nucleus
C. vesicle
D. Mitochondrion

Ans.: (D) Mitochondrion

Q.7 **Which increases the fluidity of the plasma membrane?**

a) having a large number of membrane proteins
b) the tight alignment of phospholipids
c) cholesterol present in the membrane
d) double bonds between carbon atoms in the fatty acid tails.

**Answer: (d) double bonds between carbon atoms in the fatty acid tails.**

**Q.8 Which best describes the structure of a plasma membrane?**

a) proteins embedded within two layers of phospholipids
b) phospholipids sandwiched between two layers of proteins
c) proteins sandwiched between two layers of phospholipids
d) a layer of proteins on top of a layer of phospholipids

**Answer: (a) proteins embedded within two layers of phospholipids**

**Q.9 The function of rough endoplasmic reticulum is to synthesize**

a- lipid
b- carbohydrate
c- protein that will be secreted by the cell
d- cytoplasmic protein necessary of the cell own existence
e- glycogen

**Ans.: c- protein that will be secreted by the cell**

**Q.10 Organelles involved in the process of secretion**

a- endoplasmic reticulum (rough & smooth)
b- Golgi body
c- Cell membrane
d- cytoskeleton

**Ans.: Both (a) and (b)**

**Q.11 Hydrolytic enzymes are found in**

a- Golgi apparatus
b- RER
c- SER
d- Lysosomes
**e- Ribsosomes**

**Ans.: (d) Lysosomes**

**Q.12 Ribosomes**

a- are attached to the surface of the nuclear membrane

b- are organized into polysomes in cells synthesizing intracellular proteins
c- are always associated with a strand of mRNA
d- are surrounded by a delicate thin membrane

**Ans.: b- are organized into polysomes in cells synthesizing intracellular proteins**

**Q. 13 The nucleus is**

a- always found one per cell
b- an essential organelle present in all complete cells
c- enclosed within a nuclear membrane
d- enclosed within inner, intermediate, and outer unit membrane
e- completely covered externally by the fibrous lamina

**Ans.: Both B and C**

**Q.14 Which of the following organelles is not self-replicating?**

a. Mitochondria b. Peroxisomes
c. Proteasomes d. Chloroplasts

**Ans.: Proteasomes**

**Q.15 Double membrane is absent in -**

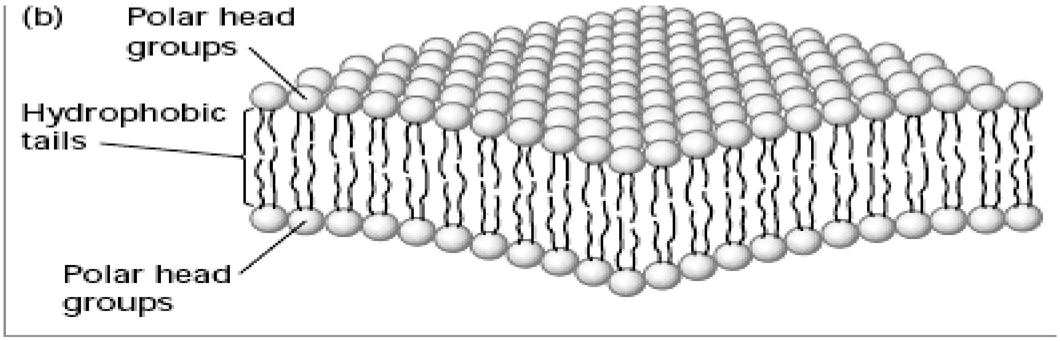
(a)Mitochondrion (b) Chloroplast (c) Nucleus (d) Lysosome

**Ans.: (d) Lysosome**

**Q.1 Give brief account on Membrane Phospholipids?**

**Ans.:** Plasma membrane is a dynamic, fluid structure and forms the external boundary of cells. It acts as a selectively permeable membrane & regulated the molecular traffic across the boundary. Basic Structure of plasma membrane is phospholipids bilayer. The plasma membrane of animal cells contain four major phospholipids such as; phosphatidyl choline, phosphatidyl serine, phosphatidyl ethanolamine, sphingomyelin.

Phospholipids are amphipathic molecules and have a hydrophobic portion & hydrophilic portion. The primary physical forces for organizing biological membranes are hydrophobic interactions between the fatty acid chains of lipid molecules. These interactions result in formation of a phospholipid bilayer sheet containing two layers of phospholipid molecules whose polar head groups face surrounding watery surface while fatty acid chain form continous hydrophobic interior.




In addition to phospholipids plasma membrane of animal cells contains glycolipids and sterol. Glycolipids contain sugar residue covalently attached to lipid. Cholesterols is especially abundant in plasma membrane of animal cells, plants prokaryotes lack the same. Fluidity of bilayer depends on its lipid composition, cholesterol content and temperature.

**Q.2 Write short note on Membrane Proteins?**

**Ans.:** Many proteins are associated with membrane they can be grouped as peripheral proteins and integral membrane proteins.

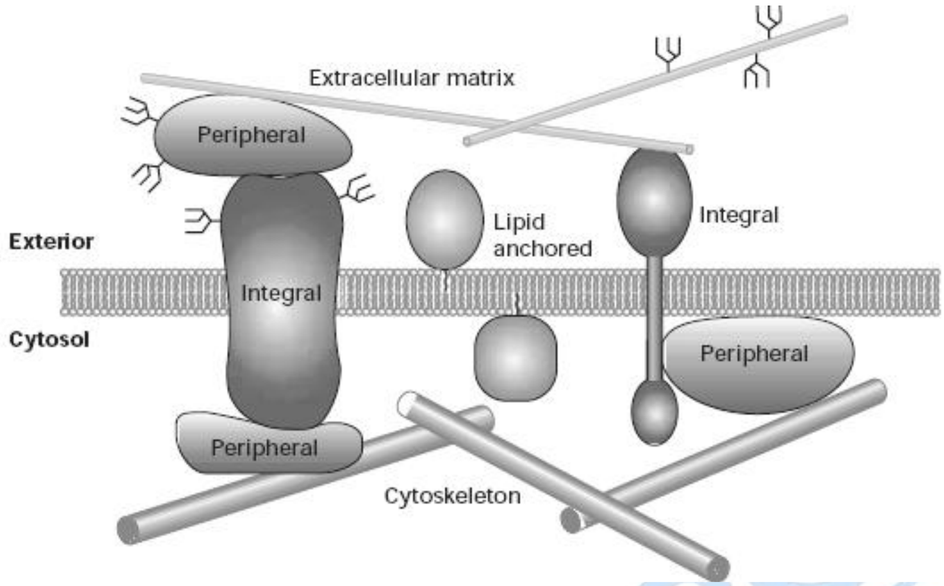
(a) **Peripheral proteins:** Also called as extrinsic proteins; they do not interact with phospholipid bilayer's hydrophobic core, instead they are usually bond to membrane indirectly by interactions with integral membrane proteins or directly by interactions with lipid polar head groups e.g. spectrin and ankyrin present in membrane of RBC.

(b) **Integral membrane proteins:** Proteins that held in bilayer by unusually tight binding to other proteins or lipids & can not be released easily are called integral membrane proteins also known as –intrinsic proteins. They have one or more segments embedded in phospholipids bilayer & contain residues with hydrophobic side chains that interact with fatty acyl groups of membrane phospholipids & thus anchoring protein to membrane. Proteins associated with membrane can be released from membrane by gentle extraction procedures such as exposure to high or low ionic strength solution or of extreme pH.

Following are the various **Types of Integral Membrane Proteins:**

(a) **Transmembrane Proteins:** Most integral proteins span entire phospholipids bilayer. They can be multi pass or single pass. Examples glycophorin and band 3 proteins present in plasma membrane of RBC.

(b) **Lipid Anchored Protein:** Some proteins are anchored to membrane by covalent bonds. In these proteins bound fatty acid is embedded in membrane, but polypeptide is chain doesn't enter into bilayer.




**Q .3 Write in detail about Mitochondria?**

**Ans.:** Mitochondria were first observed by Kolliker as globular structure in striated muscles. The present name Mitochondria was given by Benda. Mitochondria move autonomously in cytoplasm, so they generally have uniform distribution in cytoplasm.

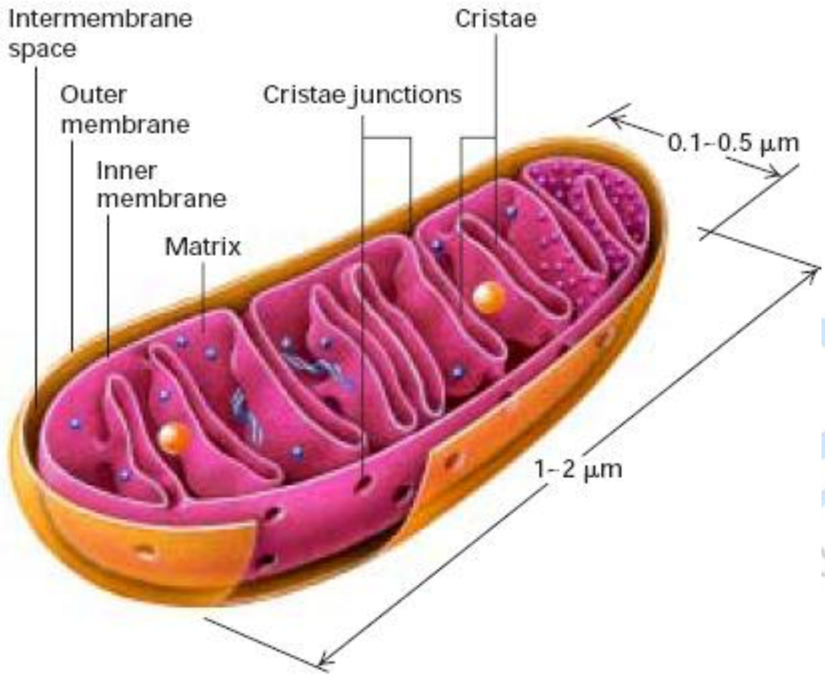
Mitochondria have definite orientation for example, in cylindrical cells; the mitochondria usually remain oriented in basal apical direction and lie parallel to main axis. The number of mitochondria in a cell depends on type and functional state of cell. It varies from cell to cell & from species to species in shape Mitochondria may be filamentous or granular in shape and may change form one shape to another. Normally mitochondria vary in size from 0.5 µm to 2.0 µm.

**Structure:** Each mitochondrion is bounded by two highly specialized membranes that play crucial part in its activities. Each of mitochondrial membrane is 6 nm in thickness and fluid mosaic in ultra structure. The outer membrane is quite smooth and has many copies of transport protein called porins which form large aqueous channels through the lipid bilayer. Inside and separated from outer membrane is present the inner membrane. The inner membrane is not smooth but is impermeable and highly convoluted forming series of infolding called cristae in matrix space. Mitochondria have double membrane envelops in which inner membrane divides the mitochondrial space into distinct chambers :

(i) Outer Compartment

(ii) Peri-mitochondrial Space

(iii) Inner Compartment or Matrix Space




Inner chamber or Matrix space is filled with dense, homogenous, gel like proteinaceous material called mitochondrial matrix. Inner membrane has an outer cytosol or C-face toward peri mitochondrial space & an inner matrix or m face toward matrix. Attached to M face of inner mitochondrial membrane are repeated units of stalked particles, called Elementary particles, inner membrane subunit oxysomes. They are also identified as F1 particles are meant for ATP synthesis.

**Mitochondrial Isolation:** Following are the three types of methods for Mitochondrial Isolation:

(i) **Direct Observation of Mitochondria:** Direct examination with vital stain called Janus Green which stains living mitochondria greenish blue due to its cytochrome oxidase activity.

(ii) **Cell Fractionation:** Mitochondria can easily be isolated by differential centrifugation at 20,000 to 40,000 g.

(iii) **Cytochemical marking:** Different parts of Mitochondria have distinct marker enzyme for histochemical marking such as cytochrome oxidase for inner membrane, malate dehydrogenases for matrix and adenylate kinase for outer chamber.

**Enzymes present in Mitochondria:**

(i) Enzymes on outer Membrane: Monoamine oxidase, cytochrome reductase, fatty acid CoA ligase & enzyme involved in lipid synthesis.

(ii) Enzymes on Inner Membrane: ATP synthetase that makes ATP in inner membrane, specific transport proteins Succinate dehydorgenase four cytochromes cyt b, cyt c, cyt $c_1$, cyt a and cyt $a_3$.

(iii) Enzymes on Inter membrane space: Enzymes require to phosphorylate the other nucleotides enzymes like adenylate kinase, nucleoside diphospokinase .

(iv) Enzymes on Mitochondrial Matrix: Enzymes that required for oxidation of pyruvate and fatty acids and for citric acid cycle or kreb cycle.

Matrix contain: Malate dehydrogenase, Isocitrate dehydorgenase, fumarase, aconitase, citrate synthetase, α-keto acid dehydrogenase.

**Q.4 Describe structure and function of Golgi apparatus?**

**Ans.:** Golgi apparatus was discovered by Camilo Golgi in 1873. It occurs in all cells except the prokaryotic cells and eukaryotic cells of certain fungi, pteridophytes. Their number per cell vary several hundred in different organisms. In animal cell they usually occurs as a single golgi apparatus,but its number may vary from animal to animal from cell to cell.

In the cell of higher plants the golgi bodies or dictyosomes are usually found scattered throughout the cytoplasm. The golgi apparatus is morphologically very similar in both plants and animal cells, the detailed structure of three basic components of the golgi apparatus are:

(i) **Flattened Sac or Cisternae :** are central, flattened plate like or saucer like closed compartments which are held in parallel bundles or stacks one above the other. Each cisternae forms dictyosome which may contain 5 to 6 golgi cisternae in animal cells. Each cisternae is bound by smooth unit membrane.

(ii) **Tubules:** Complex array of associated vesicles and anastomosing tubules.

(iii) **Vesicles :** are of three types-

(a) Transitional vesicle: Small & form as blebs from Endoplasmic vesicle and converge to golgi.

(b) Secretory vesicles: are of varied size, discharge of from margins of cisternae of golgi.

**Clathrin Coated vesicles:** Spherical protuberance found at periphery of the organelle usually at ends of single tubules & distinct from secretary vesicles.

**The GERL region:** Golgi apparatus is spatially and temporally related to endoplasmic reticulum and also found in origin of primary lysosomes. GERL is region of sorting of cellular secretary protein.

**Functions:** Golgi vesicles are often referred to as the traffic police of cell. This play a key role in sorting many of cell proteins & membrane constituents and in directing them to proper destination.

Recently in functions of golgi apparatus sub compartmentalization with a division of labour has been proposed between cis & trans golgi in which most refined proteins are further separated for their delivery to various cell compartments. Golgi apparatus is a centre for reception, finishing, packaging and dispatch for a variety of materials in animal & plants cells.

In plants Golgi apparatus is mainly involved in secretion of materials of primary and secondary cells wall. During cytokinesis of mitosis or meiosis, the vesicles, originating from periphery of Golgi apparatus coalesae in the phragmoplast area to form semi solid layer called cell plate. The unit membrane of golgi vesicles fuses during cell plate formation and becomes part of plasma membrane of daughter cells.

In animals golgi appartus is involved in packaging and exocytose of following materials :

(i) Zymogen of exocrine pancreatics cells

(ii) Mucus secretion & goblet cells of intestine.

(iii) Also involved in formation of certain cellular organelles such as plasma membrane, lysosomes, acrosome, and cortical granules of variety of oocytes.

**Q.5 Describe structure and function of Endoplasmic Reticulum?**

**Ans.:** The name endoplasmic reticulum has been coined by Porter. The occurrence of endoplasmic reticulum vary from cell to cell. The cells of those organs which are actively engaged in the synthesis of proteins such as acinar cell of pancreas, plasma cell of some endocrine glands are found to contain rough endoplasmic reticulum (RER is endoplasmic reticulum with ribosomes).

**ER & Endomembrane System:** ER is also called as cytoplasmic vacuolar system is main component of endomembrane. This system along with nuclear membrane and golgi apparatus form endomembrane system.. GERL refers to as special region of endmembrane system.

**Morphology :** ER occurs in following three forms :

(i) Lamellar form or cisternae

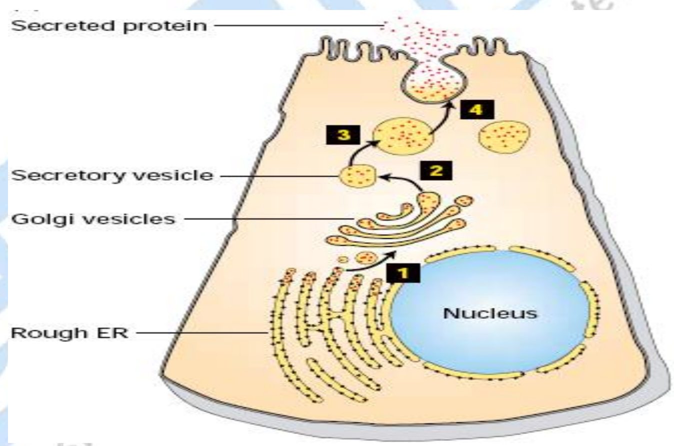
(ii) Vesicular form or Vesicles

(iii) Tubular Form or tubules

**Cisternae:** are long flattened sacs like rough endoplasmic reticulum exsist as cisternae which occur in those cells which have synthetic roles as the cells of pancreas, notochord and brain.

**Vesicles:** are oval, membrane bound vascular structure having, often remain isolated in cytoplasm & occur in most cells but abundant in smooth endoplasmic reticiulum.

**Tubules:** Branched structures forming reticular system along with cisternae and vesicles. Often found in SER & associated with membrane movements.




**Types:**

(a) **Agranular/SER:** Smooth walls because the ribosomes are not attached with its membranes. It is generally found in adipose cells, interstitial cell. Muscles are also rich in smooth endoplasmic reticulum.

(b) **Granular / RER :** Possess rough wall because ribosomes remain attached with its membrane. It is found abudantly in those cells which are active in protein synthesis such as pancreatic cells, plasma cells etc. In RER, ribosomes are often present as polysomes held together on mRNA and are arranged in rosetts or spirals.

**Origin of Endoplasmic Reticulum:** It is normally assumed that the ER has originated by evagination of nuclear membranes. The synthesis of membranes of

ER is found to proceeto in following direction RER – SER. In fact membrane biogenesis is a multi step, process involving, first synthesis of basic membrane of lipids and intrinsic proteins, thereafter addition of other constituents like sugars, lipids etc.. The process by which a membrane is modified is called membrane differentiation.

**Functions of Endoplasmic Reticulum:**

(A) **Common Functions of Granular & Agrangular :**

(i) ER provides mechanical support & skeletal framework to all

(ii) Exchange of molecules by process of osmosis, diffusion and active transport occurs through ER membranes

(iii) Contain many enzymes which perform various synthetic and metabolic activities.

(iv) It acts as an intracellular circulating or transporting system.

(v) It can form the new nuclear envelop after each nuclear decision

(vi) It plays important role in releasing column which muscle is stimulated and activity transporting colleen back into ER.

(B) **Function of Smooth ER:**

(i) Synthesis of lipids

(ii) Sterol Metabolism

(iii) Detoxification

(iv) Glycogenolysis and blood glucose homeostasis.

(v) Synthesis of triglycerides and of vesicle pigments.

(C) **Functions of Rough ER:**

(i) Synthesis of Protein

(ii) Protein glycosylation

(iii) The proteins for secretion, lysosomes and membrane formation are synthesized on membrane bound ribosome.

**Enzymes on ER Membranes**

| S.No. | Enzyme | Surface localization |
|---|---|---|
| 1 | Cytocrome $b_5$ | Cytoplasmic face |
| 2 | NADP-cytochromic C reductase | -do- |

| | | |
|---|---|---|
| 3 | ATPase | -do- |
| 4 | β- glucouronidase | Luminal face |
| 5 | Cytochrome P-450 | Cytoplasmic & Luminal face |
| 6 | GDP-Mannosyl transferase | Cytoplasmic face |

**Q.6 Write detail account on Microbodies?**

**Ans.:** Microbodies are organelle having central granular or crystalloid core containing some enzymes.

**Structure and Types :** Microbodies are spherical or oblate form bounded by single membrane and have interior or matrix which is amorphous granular. Recent biochemical studies show distinguished two types of Micorbodies namely, peroxisomes & glyoxysomes.

**Peroxysomes:** Occur in animal cells and in wide range of plants. Peroxysomes are variable in size & shape they have single unit membrane of lipid and protein molecules which encloses granular matrix.

**Function:**

(i) Peroxysomes are so called because they usually contain one or more enzymes that use molecular oxygen to remove hydrogen atoms from specific organic substrate.

$$RH_2 + O_2 \rightarrow R + H_2O_2$$

$$H_2O_2 + RH2 \rightarrow R + 2H_2O$$

of detoxify reactions. The enzymes catalase is present in peroxysomes. When excess $H_2O_2$ accumulates in cell, catalase converts $H_2O_2$ to $H_2O$.

(ii) Peroxysomes of plant leaves contain catalase together with enzymes of glycolate pathway as glycolate oxidase, gratamate glyoxylate sereire glyoxylate and aspartate & keto glutarate the slycolate cycle thought about to bring formation of aneeu a cids like glycene, serine.

(iii) In green leaves there are peroxysomes that carry out procose called photorespiration in which glocation and is released from chloroplast and owxidized into glyoxfate & H2O2 by peroxisomal enzyme called fycolic acid oxidase.

(iv) Peroxisomes of rat liver cell contain enzymes of β-oxidation for metabolism of fatty acids, the acetyl CoA formed by this process is transported to mitochondrial where it enters to citric acid cycle.

(v) Mammalian cells do not contain D-amino acid but peroxisomes of mammalian liver & kidney contain D-amino acid oxidase. Its possible role is to initiate degradation of D-amino acid that may arise from break down of peptidoglycan

(vi) **Glyoxysomes**: Found to occur in cells of yeast neurosporo and higher plants. They resemble peroxisomes in morphological details. There crystalloid core consists of dense rods of 6.0 um diameter. They have enzymes for fatty acid metabolism and glycogenesis. Glyoxysomes perform following biochemical activities of plant cells.

(i) During germination of oily seeds, the stored lipid molecules of spherosomes are hydorlysed by enzyme lipase to glycerol & fatty acids. During β-oxidation process, the fatty acid breakdown to molecules of acetyl COA molecules. In plant β oxidation occurs in seeds. In plant cells the acetyl COA, product of β-oxidation, chain is not oxidized by Kreb cycle because it remain spatially separated from the enzymes of Kreb cycle instead, acetyl CoA undergoes glyoxylate cycle to be converted into succinate.

(ii) Glyoxylate cycle occurs in glyoxysomes and it invokes some of the reactions of Kreb cycle. The citrate formed converted to isocitrate & isocitrate to glyoxylate and succinate.

$$\text{Isocitrate} \longrightarrow \text{Glyoxylate} + \text{Succinate}$$

$$\text{AcetylCoA} + \text{Glyoxylate} \xrightarrow[\text{Malate dehydrogenase}]{} \text{Malate}$$

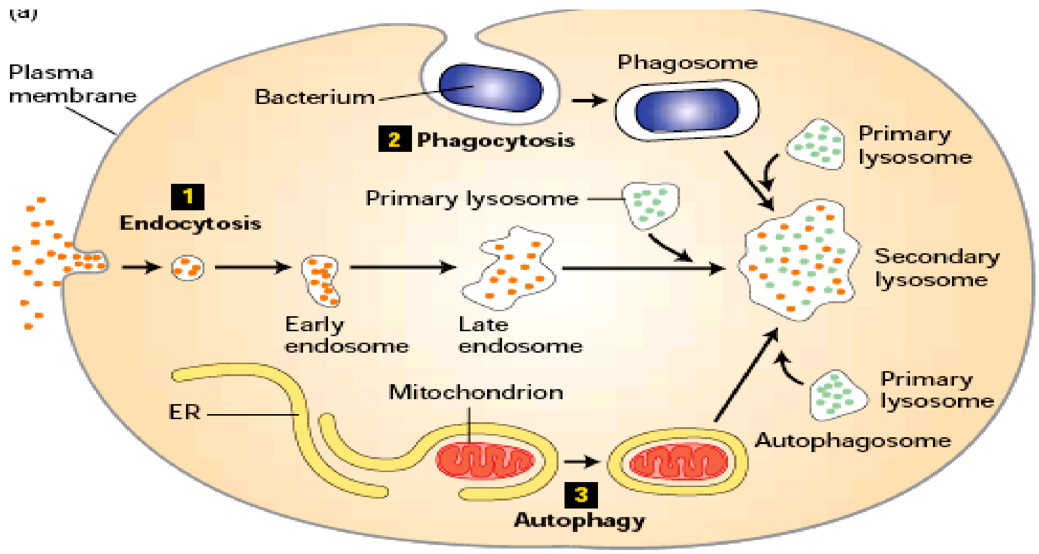
$$2\ \text{AcetylCoA} + NAD^{+} \longrightarrow \text{Succinate} + NADH + H^{+}$$

Succinate is end product of glyoxysomes metabolism of fatty acid and is not further metabolized in this organelle.

**Q.7 What are Lysosomes?**

**Ans.:** Lysosomes were initially described as perinuclear dense bodies by C. de Duve renamed these organelles as Lysosomes to indicate the internal digestive enzymes only become apparent than the membrane of these organelles as lysed.

Lysosomes occur in most animal and plant cells, absent in mature mammalian RBC. They occur in abundance in epithelial cell of lungs and uterus. Phagocytic cells and cells of reticulo endothelial system are also rich in lysosomes.




**Structure:** Lysosomes are round vacuolar structures which remain filled with dense material bounded by single unit membrane.

It should contain two or mores acid hydordases and should demonstrate the property of enzyme.,when treated in a way that adversary effects organelle's membrane structure.

**Lysomal enzymes:** Lysosomes contain 40 types of hydrolytic enzymes, they include proteases, nucleases, glycosidases, lipases, phospholipases, phosphatases sulphatases. All lysosomal enzymes are acid hydrolases. Acid dependency of lysosomal enzymes protects the contents of cytosol against any damage if leakage of lysosomal enzymes should occur.

**Function of Lysosomes :**

(i) Digestion of Large extra cellular particles which enables to devour the foreign bacteria of verieses

(ii) Digestion of intracellular substances like protein, lipids and carbohydrates of the cytoplasm & supply to cell, necessary amount of energy.

(iii) **Autolysis or Cellular Autophagy :** In pathological conditions the lysosomes start to digest the various organelles. When cell dies, the lysosmal membrane ruptures and enzymes are liberated. These enzymes digest dead cell.

(iv) **Extra Cellular Digestion:** The lysosomes of certain cells such as sperms discharge their enzymes outside the cell during the process of fertilization, the lysosomal enzyme digest the limiting membrane of ovum and forms penetration ratio. Acid hydrolases are also released from osteoclast & break down bone for the reabsorbtion.

**Lysosome and Disease:** Malfunctioning of lysosome often results in various pathological disorders eg; Tay Sachs disease which is inborn disorder, other induced by environmental pollution eg; s silicosis.

**Lysosomes in Plants :** Plant contain several hydrolases. Plant lysosomes can be defined as membrane bound cell compartment containing hydrolytic digestive enzyme. vacuoles in plants have been divides in following types:

(a) **Vacuoles:** formed by fusion of to small provacuoles which are believed to be derived from ER and Golgi and contain acid hydrolases. Enzymes are associated with tonoplast of large Vacuole of differentiating cells.

(b) **Spherosomes :** Membrane bound spherical particles occurring in most plant cells they have fine granular structure rich in lipids and proteins. They originate from ER, like lysosomes they are not only responsible for the accumulation and mobilization of reserve lipids but also for the digestion of other cytoplasmic components in corporated by phagocytosis.

(c) **Aleurone Grains:** The aleurone Grains or protein bodies are spherical membrane bound storage particles occurring in cells of endosperm and cotyledons of seed they are formed during later stages of seed ripening and disappear in early stages of germination. Thus like spherosome, aleurone store reserve materials, mobilize them during germination and in addition form comportment for digestion of other cell components.

**Q.8 Describe structure and function of Nucleus.**

**Ans.:** Nuclei were first discovered and named by Robert Brown and were quickly recognized as constant feature of all animal and plant cells. Nucleoli was first noticed by Fontana , Strasburger introduced the term cytoplasm and nucleoplasm.

Nucleus is found in all eukaryotic cells of plants and animals. However mammalian erythrocyte contains no nucleus. The prokaryotic cells of bacteria do not have true nucleus i.e single circular and large DNA molecules remains in direct contact with cytoplasm. Usually nucleus remains located in the centre. But its positions may change time to time according to metabolic status e.g., in embryonic cells nucleus generally occupies geometric centre of cells but as the cell start to differentiate, displacement in nucleus position will take place.

**Morphology:** Usually cells contain single nucleus but the number of nucleus may vary from cell to cells, most plant and animal cells are uninucleate. The shapes of nucleus remain related to shape of cell. The nuclei of cylindrical, prismatic or fusiform cell contain ellipsoid nucleus whereas, cells of squamous epithelium contain discoidal nuclei.

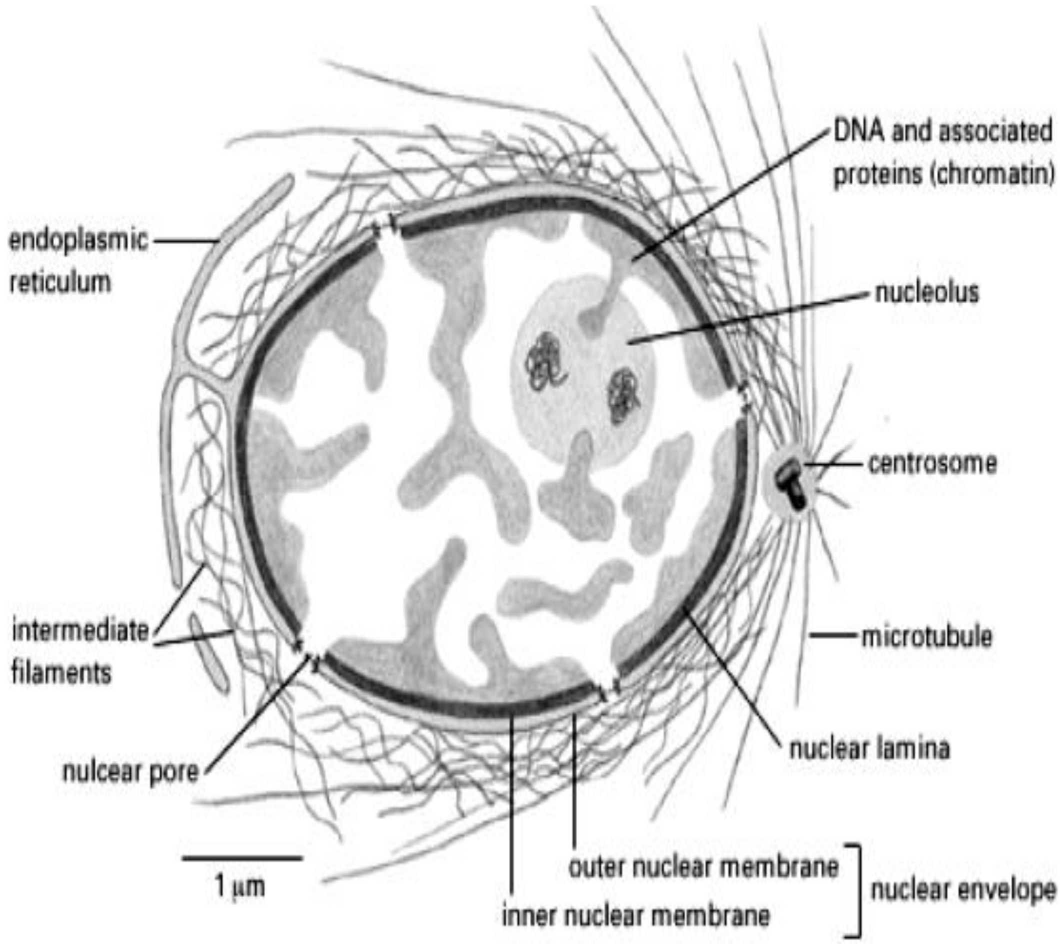
**Ultra-structure:**

(i) **Nuclear Envelope:** Nuclear envelope encloses DNA and defines the nuclear compartment of inter phase and prophase nuclei. It is formed of true concentric unit membranes, the spherical inner nuclear membrane contain specific proteins that act as binding site for supporting fibrous sheath of inter mediate filaments called nuclear lamina. The inner nuclear membrane is surrounded by the outer nuclear membrane which closely resembles the membrane of endoplasmic reticulum, outer surface of outer membrane has ribosomes engaged in protein synthesis The space between inner and outer membrane is called peri nuclear space. The perinuclear space is fluid filled compartment which is continuous with ER lumen.

(ii) **Nuclear Lamina:** Also called fibrous lamine It is a protein meshwork and present inside surface of inner nuclear membrane, except the areaof nucleopores and consist of intermediate filaments also it is very dynamic structure. In mammalian cells undergoing mitosis, the transient phosphorylations of several serine residues on lamins causes the lamina to dissamble.

(iii) **Nuclear Pore Complex:** The nuclear envelop in all eukaryotic forms is perforated by nuclear pores, nuclear pore appear circular in surface view and diameter between 10 nm -100 nm. Nuclear pore complex consists of two rings at it periphery and large particle that forms a central and radial spokes ,partices anchored to cytoplasmic ring are thought to bind ribosomes. The hole in the centre of pore complex is aqueous channel through which water soluble molecules shuttle between nucleus and cytoplasm. In nuclei of mammals it has been calculated that nuclear pores account for 5-15% of surface area of the nuclear membrane. The number of pores in nuclear envelop or pore density correlate with activity of cell. Nuclear pore are evenly distributed in somatic cells, however in other cell pores are arranged in rows or clusters.

(iv) **Nucleoplasm :** Space between nuclear envelop and nucleus is filled with ground substance or matrix called nuclear sap or nucleoplasm.




**Q.9 Describe Plant & Bacterial Cell Wall.**

**Ans.:** The plant cells is always surrounded by cell wall which is a nonliving structure formed by living protoplast. It is rigid and protective layer around the plasma membrane which provides mechanical support to the cell. It also determines the shape of plant cell.

**Cellulose :** The polysaccharide of cell wall include polymer of glucose unit linked by 1-4 β glycosidic bonds. Its structural units known as micro fibrils which get associated with macrofibrils. Hemicullose are short but branched heteropolymers of various monosaccharides. Some of common eg: of hemicellulose are xylans, glucomannans

**Pectins :** Water soluble, heterogenous branched polysaccharide that contain many negatively charged D- galatouronic acid residues along will D-glucuronic acid residues ,they are helpful in keeping cell wall component together. Mannans, agar, lignin and chitin are also present in cell wall.

**Cutin :** Is a biological plastic and is made of fatty acid. Suberin is water resistant substance, comprising of fatty acid and found in Cork and Cell wall of many plants.

**Structure:**

(i) **Primary Cell Wall:** First formed cell wall, outer most layer of cell and comparatively thin, the primary cell wall of yeast and fungi is composed of chitin.

(ii) **Secondary Cell Wall:** Primary cell wall is followed by secondary cell wall. It is thick permeable and composed of compactly arranged macrofibrils of cellulose.

(iii) **Tertiary Cell Wall:** There occurs another cell wall beneath the secondary cell wall called as tertiary cell wall. Tertiary differs in staining, chemical composition, besides cellulose, tertiary wall also consist of xylem.

**Middle Lamella:** Cell of plant tissues generally remain cemented together by an inter cellular matrix known as middle Lamella. It is mainly composed of pectin and lignin. Each plant cell is interconnected with each other through cytoplasmic channels called Plasmodesmata which pass through intervening cell wall.

**Origin and Growth of Cell Wall:** It includes formation of matrix and synthesis and orientation of cellulose microfibrils. Extension of cellulose microfibril is presumably achieved by lateral movement of enzyme complex in fluid phase of plasma-membrane. During lignifications, lignin is deposited in spaces between the cellulose molecules making cell wall more rigid rendering it impermeable. The lignified tissue becomes well adapted to two types of functions:

(i) It provides mechanical strength due to it lingo- cellulose composition

(ii) It transports water & salts, since lignifications involve loss of the protoplasm resulting in formation of hollow waterproof tube.

**Bacterial Cell Wall:** Present outside plasma membrane in all the bacteria. It is very thick in gram positive bacteria and is comparatively thin in gram negative bacteria. The cell wall in bacteria is much more complex then cellulose wall of plant cells. It is formed of mucopeptide, polysaccharide, amino acid and lipid.

**Polysaccharides:** Forms backbone of cell wall and confer structural rigidity, the polysaccharide of bacterial wall formed of sugars like glucose, galactose.

(i) N-Acetyl Muramicic Acid

(ii) N-Acetyl Glucosamine

They are arranged alternatively and joined by glycosidic linkages. In gram positive bacteria matrix of cell wall formed of teichoic acid which is polymers of glucose, alanine and glycerol or Ribitol. Techoic acid has glycerol or ribitol phosphate and only one of the two can be present in cell wall of particular strain of gram positive bacteria.

In gram negative bacteria there is no teichoic acids and only 5-10% peptidoglycans present which protect cell from osmotic rupture and provide rigidity and shape to cell wall. Teichoic acids if present obtain $Mg^{+2}$ from environment for metabolic function of cell.

Amino acid: Amino acid present are glutamic acid, alanine, glycine, and lysine. In gram positive bacteria amino acids are alanine & glycine which are present in large proportions.

**Lipids:** About 20% lipid present in cell wall of gram negative bacteria and in gram positive bacteria only traces of lipid found.

| S.No. | Gram Positive Bacteria | Gram Negative Bacteria |
|---|---|---|
| 1. | Cell Wall is thick. | It is thin. |
| 2. | 95% Peptidoglycans. | Peptidoglycans are 5-10%of cell wall. |
| 3. | Teichoic acid present. | Absent. |
| 4. | Lack LPS- lipopolysaccharides | Cell wall contains LPS which make them virulent |
| 5. | Four types of amino acids are present in major proportion that's mainly include glycine, alanine | Many types of amino acids are present. |

Difference between gram positive & gram Negative bacterial cell wall.

□ □ □

# Section-B

## Chapter-1

# Important Properties of Water

**Q.1 In a single molecule of water, two hydrogen atoms are bonded to a single oxygen atom by**

A) hydrogen bonds.
B) nonpolar covalent bonds.
C) polar covalent bonds.
D) ionic bonds.
E) van der Waals interactions.

**Ans.: B) nonpolar covalent bonds.**

**Q.2 An example of a hydrogen bond is the bond between**

A) C and H in methane ($CH_4$).
B) The H of one water molecule and the O of another water molecule.
C) Na+and Cl- in salt.
D) the two hydrogen atoms in a molecule of hydrogen gas ($H_2$).
E) Mg+and Cl- in $MgCl_2$.

**Ans.: B) the H of one water molecule and the O of another water molecule.**

**Q.3 Water is able to form hydrogen bonds because**

A) oxygen has a valence of 2.
B) the water molecule is shaped like a tetrahedron.
C) the bonds that hold together the atoms in a water molecule are polar covalent bonds.
D) the oxygen atom in a water molecule has a weak positive charge.
E) each of the hydrogen atoms in a water molecule is weakly negative in charge.

**Ans.: C) the bonds that hold together the atoms in a water molecule are polar covalent bonds.**

**Q.4 What gives rise to the cohesiveness of water molecules?**

A) hydrophobic interactions
B) nonpolar covalent bonds
C) ionic bonds
D) hydrogen bonds
E) both A and C

**Ans.: D) hydrogen bonds**

**Q.5 Water molecule has characteristics of**

(A) Acid
(B) Base

(C) Both acid and base
(D) None of these

**Ans.: C) Both Acid and Base**

**Q.6 A substance that prevents large changes in the pH of a solution is**
A. DNA.
B. water.
C. a buffer.
D. an enzyme.

**Ans.: C. a buffer.**

**Q.7 If the pH of a solution changes from 2 to 5, then the solution has**
A. become a base.
B. lost hydrogen ions.
C. become more acidic.
D. gained hydrogen ions.

**Ans.: B. lost hydrogen ions.**

**Q.8 Water allows chemical reactions in cells to occur because it**
A. acts as a solvent.
B. evaporates readily.
C. is less dense as a solid.
D. promotes dehydration synthesis

**Ans.: A. acts as a solvent.**

**Q.9 Water molecules are connected to each other by**
A. buffers.
B. hydrolysis.
C. peptide bonds.
D. hydrogen bonds.

**Ans.: D. hydrogen bonds.**

**Q.10 Which of the following is necessary for hydrogen bonding?**
A. Peptide bonds.
B. Hydrogen ions.
C. Polar molecules.
D. Equal sharing of electrons.

**Ans. C. Polar molecules.**

**Q. 1 Define Buffer?**

**Ans.:** A Buffer solution is one that resists a change in pH after addition of acid ($H^+$) or base ($OH^-$) more effectively than an equal volume of water.

**Q.2 What are the unique features of Water?**

**Ans.:** Following are the unique features of water:

(1) Water is universal solvent.

(2) It adheres and cohesive.

(3) Resists changes in temperature

(4) Resists change of state.

**Q.3 Summarize the physical properties of Water?**

**Ans.:** Physical Properties of water are:

| Property | Value |
|---|---|
| Melting Point : | 0ºC |
| Boiling Point : | 100ºC |
| Heat of Vaporization : | 540 cal/g |
| Heat Capacity : | 1000 cal/g |
| Heat of Fusion : | 79.7 cal/g |
| Surface Tension : | 72.8 |
| Dielectric Constant : | 80 |

**Q.4 What are the properties of Water of physiological importance?**

**Ans.:** (1) Expansion on freezing and frozen water is less dense than liquid water.

(2) High surface tension because of which water rises in narrow capillary tube.

(3) High heat capacity and thus water act as temperature buffer.

(4) High solvent power and therefore it is called universal solvent which facilitates chemical reactions both outside and within biological systems.



**Q.5 State Law of Mass Action? What is ionic product of Water?**

**Ans.:** Low of Mass Action states, "The rate of a chemical reactions is directly proportional to product of molar concentrations reactants at a constant temperature at a given time."

e.g. $A + B \rightarrow$ Products

Thus, Rate of reaction r $\alpha$ [A] [B]

=k [A] [B] where [A] and [B] are molar concentrations of reactants A & B respectively. k is constant of proportionality called rate constant.

For, reversible reaction A + B ---- X + Y

$$K_{eq} = \frac{[X][Y]}{[A][B]} \qquad K_{eq} = \text{equilibrium constant}$$

Water molecule have slight tendency to under go reversible ionization crucial to role of water in cellular functions.

$$H_2O \rightleftharpoons H^+ + OH$$

From Law of Mass action; the equilibrium constant for reversible ionization of water can be given by

$$K_{eq} = \frac{[H^+][OH^-]}{[H_2O]} \qquad \text{\_ \_ \_ (1)}$$

In pure water at 25°C concentration of water is 55.5 M. On substituting 55.5 M in equilibrium constant expression.

$$Keq = \frac{[H^+][OH^-]}{55.5M} \qquad \text{\_ \_ \_ (2)}$$

or (55.5 M) (Keq) = $[H^+][OH^-]$ = Kw $\qquad$ _ _ _ (3)

Kw = (Keq) (55.5 M) is called as:

Ionic Product of water

Value for Keq = $1.8 \times 10^{-16}$M at 25° C

$\therefore$ (55.5) ($1.8 \times 10^{-16}$) = $[H^+][OH^-]$

Or $1.0 \times 10^{-14} M^2 = [H^+][OH^-]$ = Kw

If in solution there is equal concentration of $H^+$ & $OH^-$ then,

Kw = $[H^+]$ $[H^+]$ $\qquad$ as, [OH] = $[H^+]$

Kw = $[H^+]^2$

Or $\sqrt{Kw} = H^+ = \sqrt{1 \times 10^{-14} M^2} = 10^{-7}$ M

**Q.6 Define pH. Why it is required to maintain pH?**

**Ans.:** Sorensen defines pH of a solution as the negative logarithm of concentration of hydrogen ions.

Thus, $\quad pH = \log \dfrac{1}{[H^+]} = -\log [H^+]$

The symbol p denotes "negative logarithm of ".

For, precisely natural solution at 25° C, in which concentration of hydrogen ion is 1.0 x $10^{-7}$ M pH can be calculated as:

$$\begin{aligned} pH &= \text{Log} \frac{1}{1\times10^{-7}} = -\log(1 \times 10^7) \\ &= \log 1.0 + \log 10^7 \\ &= 0 + 7.0 \\ &= 7.0 \end{aligned}$$

Measurement of pH is one of the most important and frequently used procedures in biochemistry. It is required to maintain pH because it affects structure and activity of biological macro molecules for e.g. catalytic activity of enzymes.

**Q.7 Write about Brownsted Acids?**

**Ans.:** In aqueous systems addition or removal of hydrogen ion is explained by Brownsted-Lowry concept of acids and bases.

A Brownsted Lowry acid is defined as substance that can donates a proton ($H^+$) and Brownsted Lowry base is substance that can accept a proton. A proton donor (acid) and corresponding proton acceptor (base) make up conjugate acid base pair.

$$HA \rightarrow H^+ + A^-$$

Here, HA represent Brownsted Lowry acid.

**Q.8 Write in brief on Ionizations of weak Acid?**

**Ans.:** Weak acid is molecule that has a lesser tendency to lose its proton and therefore does not readily dissipate in water for e.g. Acetic acid ($CH_3$ COOH).

The dissociation of weak organic compound, acetic acid is written as:

$$CH_3COOH \rightarrow H^+ + CH_3COO^-$$

At a given temperature, extent of ionization at equilibrium can be given by following equation.

$$Ka' = \frac{[H^+][CH_3COO^-]}{[CH_3COOH]}$$

Ka'- apparent ionization constant.

For 1M acetic acid, Ka = 1.8 x $10^{-5}$ M at 25° C if [H+] & [$CH_3$ $COO^-$] = x

$x^2 = 1.8 \times 10^{-5}$

$x = 4.2 \times 10^{-3}$ M

$= 0.0042$ M

**Q.9 What is Henderson Haessel Bach Equation?**

**Ans.:** The quantitative relationship among pH, buffering action of mixture of weak acid with its conjugate base, and the pka of weak acid is given by a simple expression called Henderson Haesselbach equation. The shape of titration curves of weak acid is also expressed by this equation .It is simply a useful way of restating expression for dissociation constant of a weak acid. For dissociation of a weak acid HA into H+ and A-, the Henderson Haesselbach equation can be derived as;

$$Ka = \frac{[H^+][A^-]}{[HA]}$$

Or $$[H^+] = Ka\frac{[HA]}{[A^-]}$$

Taking log

$$\log [H^+] = \log Ka + \log \frac{[HA]}{[A^-]}$$

taking negative log both side;

$$- \log [H^+] = - \log Ka - [\log \frac{[HA]}{[A^-]}]$$

Substitute pH for – log [H+] and pKa for – log Ka

$$\therefore\ pH = pKa - [\log \frac{[HA]}{[A^-]}]$$

Or $$pH = pKa + \log \frac{[A^-]}{[HA]}$$

In more general form;

$$pH = pKa + \log \frac{[\text{Proton acceptor}]}{[\text{Proton donor}]}$$

This equation fits titration curve of all weak acids and enables to deduce a number of important quantitative relationships.

**Q.10 Explain Buffering Action of following Biological or Physiological Buffers.**

**OR**

**Write a short note on Buffers.**

**(a) Phosphate Buffer System.**

**(b) Bicarbonate Buffer system.**

**Ans.: (a) Phosphate Buffer System:** This system acts in cytoplasm of all cells consist of $H_2PO_4$ as proton donor and $HPO_4^{2}$ as proton acceptor.

$$H_2PO_4^- \rightarrow H^+ + H\,PO_4^{2-}$$

The phosphate buffer system is effective at pH close to its pka of 6.86 and thus tends to resist pH changes in range between 6.4 & 7.4, the pH of intracellular fluids (6.0–6.9) is nearer to pKa of phosphate buffer & therefore buffering capacity of phosphates buffer is highly elevated inside the cells.

In case the ratio of $[HPO_4^{2}]$ / $[H_2PO_4^-]$ tends to be changed by formation of more $H_2PO_4^-$ for which the ratio ultimately remains unaltered.

**(b) Bicarbonate Buffer System:** this is main extra cellular buffer system which provides means for removal of $CO_2$ produced by tissue metabolism. It is the main buffer system in blood plasma and consists of carbonic acid as proton donor and Bicarbonate as proton acceptor.

$$H_2CO_3 \rightarrow H^+ + HCO_3^-$$

$$K_1 = \frac{[H^+][HCO_3^-]}{[H_2CO_3]}$$

One of its components $H_2CO_3$ [Carbonic acid] formed from dissolved $CO_2$ & $H_2O$.

$$CO_2\,(d) + H_2O \rightarrow H_2CO_3$$

$$K_2 = \frac{[H_2CO_3]}{[CO_3(d)][H_2O]}$$

Also, $CO_2\,(g) \rightarrow CO_2\,(d)$

The pH of bicarbonate buffer system depends on concentration of $H_2CO_3$. The concentration of $H_2CO_3$ depends on concentration of dissolved $CO_2$ which in turn depends on concentration of $CO_2$ in gas phase.

**Q.11 Explain titration of a weak acid by a strong base with help of titration curve?**

**Ans.:** The concentration of acid in original solution can be calculated from volume and concentration of NaOH added. A plot of pH against amount of NaOH added reveals pKa of weak acid.

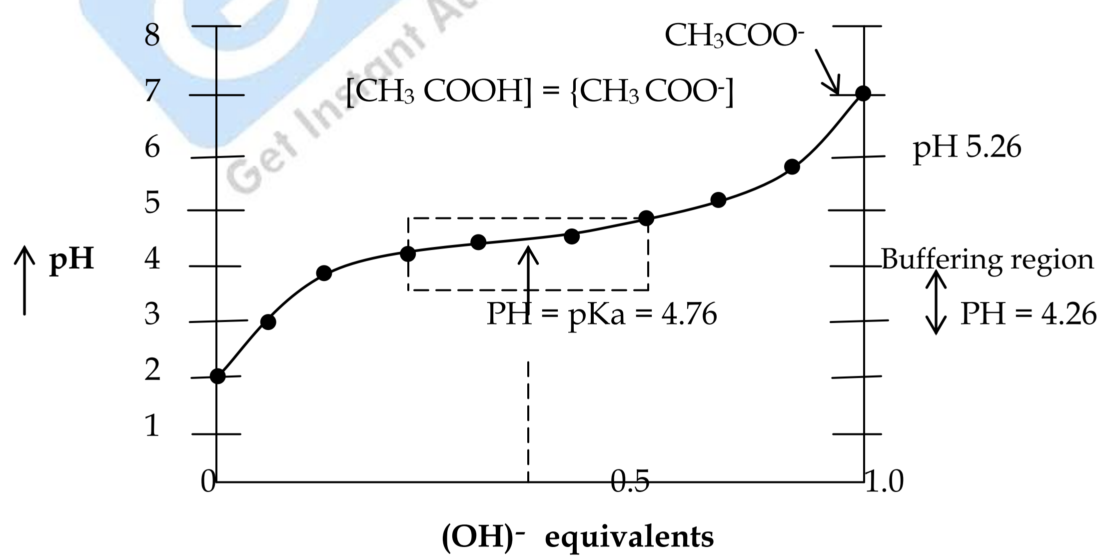
Equilibrium constant for ionization reaction are called dissociation constant ka, pka which is analogous to pH can be given by

$$pKa = \log \frac{1}{Ka} = -\log Ka$$

Titration curve reveals property of acids and their conjugate base.

When acetic acid is titrated with NaOH, the greatest changes in pH takes place at beginning of and end of titration. The region of least change occurs at mid point of titration. When exactly 0.5 equivalents of base have been added at this point concentration of undissociated acid $CH_3$ COOH or HA is equal to its anion ($CH_3$ $COO^-$ or $A^-$). At these particular concentrations of HA and $A^-$ , the pH {4 .6} is equal to pKa.

After the addition of each increment of NaOH to acetic acid solution, the pH of mixture is measured. This value is plotted against fraction of total amount of NaOH required to neutralize acetic acid. The points so obtained yield titration curve.



At mid point of titration concentration of proton donor and acceptor are equal and is called screened zone, is useful region of buffering action.

□ □ □

# Chapter-2

# Biomolecules

**Q.1 Which of the following is not a reducing sugar?**
A) Glucose
B) Fructose
C) Galactose
D) Sucrose
E) Lactose
**Ans.: D) Sucrose**

**Q.2** The general formula of monosaccharides is
A) CnH2nOn
B) C2nH2On
C) CnH2O2n
D) CnH2nO2n
**Ans.:** A) CnH2nOn

**Q.3 Polysaccharides are**
(A) Polymers
(B) Acids
(C) Proteins
(D) Oils
**Ans.: (A) Polymers**
**Q.4 Two sugars which differ from one another only in configuration around a single carbon atom are termed**
(A) Epimers
(B) Anomers
(C) Optical isomers
(D) Stereoisomers
**Ans.:** (A) Epimers

**Q.5 The number of isomers of glucose is**
(A) 2
(B) 4
(C) 8
(D) 16
**Ans.: (D) 16**

**Q.6 Starch is a**
(A) Polysaccharide
b(B) Monosaccharide
(C) Disaccharide
(D) None of these
**Ans.: (A) Polysaccharide**

**Q.7 Number of asymmetric carbon atom in glucose is:**
A. One
B. Two
C. Three
D. Four

**Ans.: D. Four**

**Q.8 Monosaccharides can be seperated by:**
A. Electrophoresis
B. Chromotography
C. Salting out
D. None of the above

**Ans.: B. Chromotography**

**Q.9 Alpha-D-Glucuronic acid is present in:**
A. Hyaluronic acid
B. Chondrointin sulphate
C. Heparin
D. All of the above

**Answer: C. Heparin**

**Q.10 Maltose can be formed by hydrolysis of:**
A. Strach
B. Dextrin
C. Glycogen
D. All of the above

**Answer: D. All of the above**

**Q.11 Write two examples of each Disaccharides and Trisacchharides -**
**Ans.:** Disaccharide - Sucrose, Maltose
Trisaccharide - Raffinose, Rhaminose

**Q.12 Give example of Reducing Sugars and Non-reducing Sugar.**

**Ans.:** Reducing Sugar – Glucose

Non Reducing Sugar – Sucrose

**Q.13 Define Carbohydrates?**

**Ans.:** Carbohydrates are polyhydroxy aldehydes or ketones and their derivatives also known as sugars or saccharides.

**Q.14 What are Polysaccharides?**

**Ans.:** Polysaccharides are sugars that yield more than 10 molecules of monosaccharide on hydrolysis; their general formula is $(C_6H_{10}O_5)X$.

They are of two types:

(a) Homo Polysaccharide (*e.g. Starch, Glycogen*)

(b) Hetero Polysaccharides (*e.g. Hyaluronic Acid, chondrotin*)

**Q.15 What are Enantiomers?**

**Ans.:** The two D and L forms of a compound constitute a pair of enantiomers or enantiomorphs. Enantioners are optically active stereoisomers which are mirror images of each other.

**Q.16 D–Glucose is –**

(a) Dextrorotatory (b) Levorotatory

(c) Both (d) None **Ans.: (a)**

**Q.17 Write reaction of Fehling's Reagent with Reducing Sugar?**

**Ans.:**

$$\underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fehling's Solution}}{2Cu(OH)_2} \longrightarrow \text{Gluconic Acid} + \underset{\text{Cuprous Oxide (Red Color)}}{Cu_2O} + H_2O$$

**Q.18 What is difference between reducing and non reducing sugars?**

**Ans.:** Carbohydrates with free aldehyde (at C-1) or free ketone at (C-2) group are called reducing sugars, and if aldehyde or ketone group is not free but instead utilized in bond formation is called non reducing sugar.

**Q.19 What are disaccharides and how they are classified?**

**Ans.:** Disaccharides are most common oligosaccharide and yield 2-10 monosaccharides on hydrolyses.

Disaccharides

- Non reducing
  - $C_1 - C_1$ glycosidic linkage → e.g. Trohalose
  - $C_1 - C_2$ glycosidic linkage → Sucrose
- Reducing
  - $C_1 - C_4$ glycosidic linkage → Maltose
  - $C_1 - C_6$ glycosidic linkage → Melibiose

**Q.20 Explain structure and properties of any one disaccharide.**

**Ans.:** Sucrose is disaccharide and is widely distributed in photosynthetic Plants.

In plants molecule of water form glycoside of hydroxyl groups or (- 1) glucose and B – D, Fructose.

It is white crystalline solid, soluble in water and with melting point 180º C.

It is dextrorotatory and is non-reducing sugar.

**Structure**

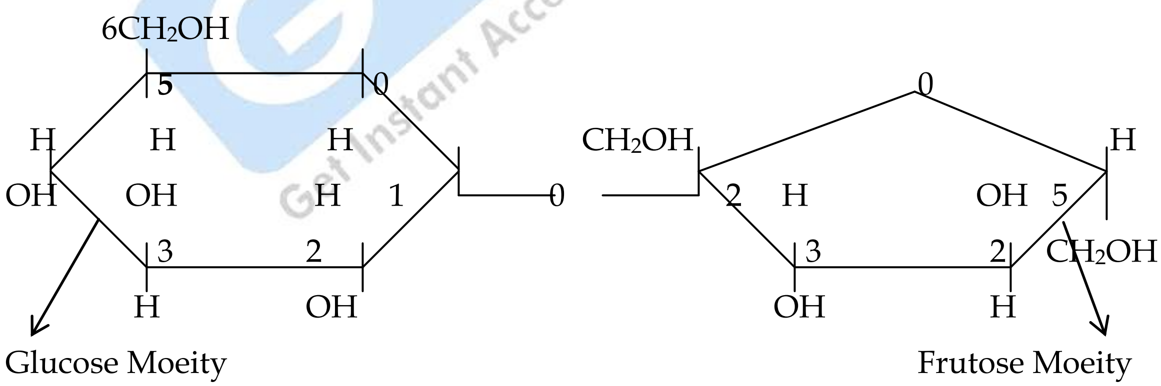



**Fig. : Sucrose**

Upon hydrolyses Sucrose yields equimolar. Mixture glucose and fructose which is often called a revert sugar.

$C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6 + C_6H_{12}O_6$

Sucrose      water      Glucose      Fructose

On hydrolysis sucrose gives mixture of equimolar quantities of D (+) glucose (dextrorotatory) and D (-) fructose levorotatory.

This mixture is also called as invert sugar and reaction inversion of sucrose is catalyzed by enzyme invertase.

**Q.21 What is Glycogen or animal starch?**

**Ans.:** Major reserve food in animals often called as animal starch. Glycogen is stored in liver and muscles of animals. It is branded clean Polysaccharide, whose molecular weight is 1-2 x $10^7$.

It is white powder and Soluble in water. It is non reducing sugar. On incomplete hydrolysis it yields Maltose and on complete hydrolysis by acids it gives Glucose.

$(C_6H_{10}O_5)n + (n - 1)\ H_20 \rightarrow n\ (C_6H_{12}O_6)$

Glycogen      n – 1 water      n glucose mole cutes
(soluble)

**Q.22 Polymers of amino acid are?**

(a) Proteins      (b) Carbohydrates

(c) Lipids      (d) Peptide

**Ans.: (a) Proteins**

**Q.23 Which form of amino acids are commonly found in Eukaryotes?**

(a) D – form      (b) D & L form

(c) L – form      (d) None

**Ans.: (c) L- form [L = laevorotatory]**

**Q.24 How many standard amino acids are present?**

(a) 20      (b) 30

(c) 10      (d) 15      **Ans.: (a)**

**Q.25 Amino acids are:**

(a) Polar      (b) Non Polar

(c) Uncharged      (d) Amphoteric      **Ans.: (d)**

**Q. 26 An example of chromoprotein is**
(A) Hemoglobin
(B) Sturine
(C) Nuclein
(D) Gliadin

**Ans.: (A) Hemoglobin**

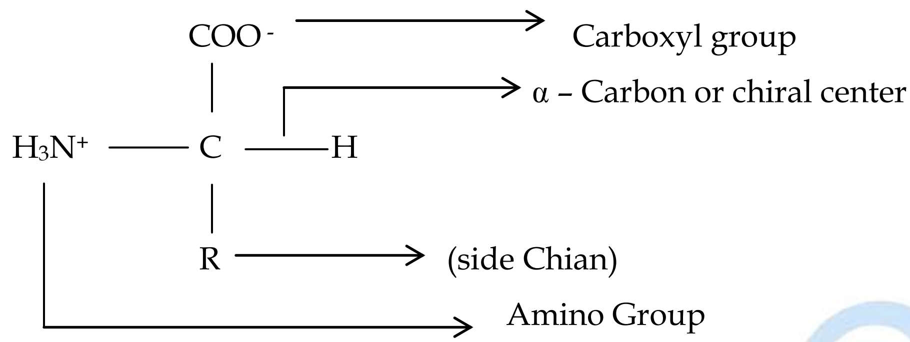
**Q.27 Casein, the milk protein is**
(A) Nucleoprotein
(B) Chromoprotein
(C) Phosphoprotein
(D) Glycoprotein

**Ans.: (C) Phosphoprotein**
**Q.28 Two amino acids of the standard 20 contain sulfur atoms. They are:**
a. cysteine and serine
b. cysteine and threonine
c. methionine and cysteine
d. methionine and serine

e. threonine and serine
**Ans.: c. methionine and cysteine**
**Q.29 A peptide bond forms by:**
a). a condensation reaction.
b). dehydration synthesis.
c). the formation of a covalent bond.
d). all of these.
**Ans.: d) all of these**
**Q.30 The level of protein structure represented by the alpha-helix shape is**
A. primary.
B. secondary.
C. tertiary.
D. quaternary.
**Ans.: B. secondary.**
**Q.31 Proteins may denature when**
A. pH is changed.
B. oxygen is present.
C. they form enzymes.
D. substrate concentration is increased.
**Ans.: A) pH is changed.**
**Q.32 When a protein loses its normal three-dimensional configuration, it is said to be**
A. saturated.
B. denatured.
C. neutralized.
D. synthesized.
**Ans.: B. denatured.**

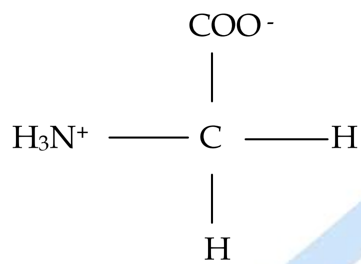
**Q. 33 Write general structure of amino acid?**

**Ans.:**

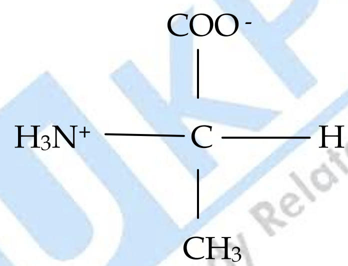



**Q.34 Give structure of any five amino acids with nonpolar, aliphatic R group?**

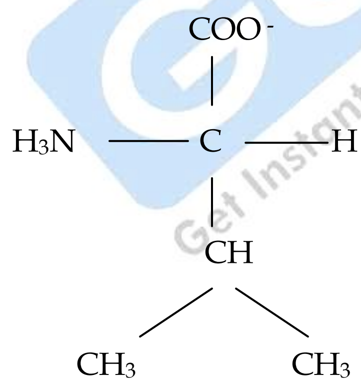
**Ans.:**



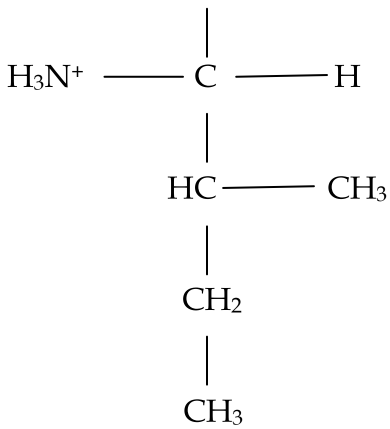

**Glycine**



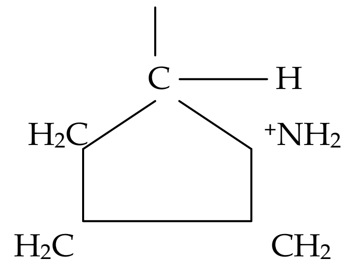

**Alanine**




**Valine**

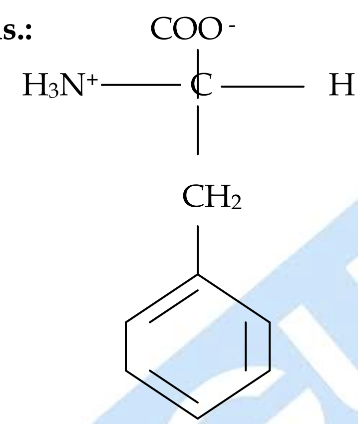

**Isoleucine**



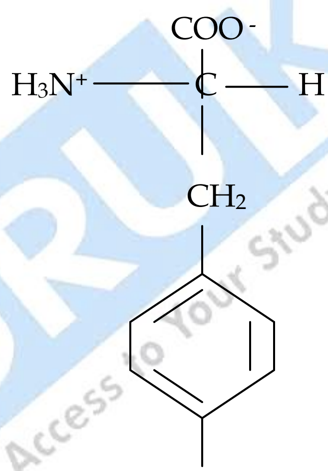

**Proline**

**Q.35 Give structure of amino acid with aromatic R group?**

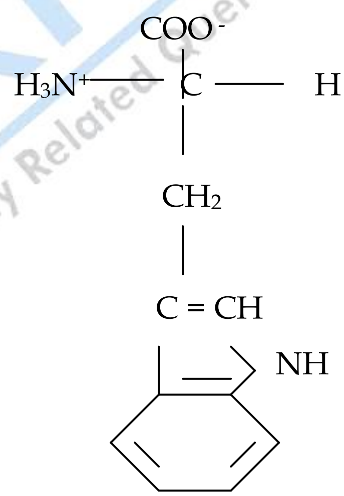
**Ans.:**




**Phenylalanine**



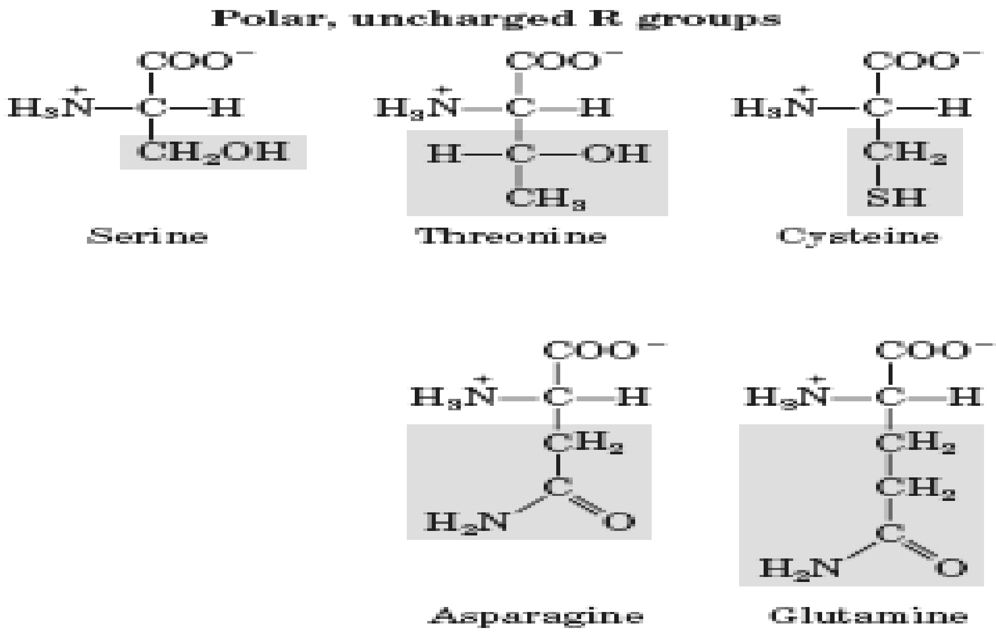

**Tyrosine**




**Tryptophan**

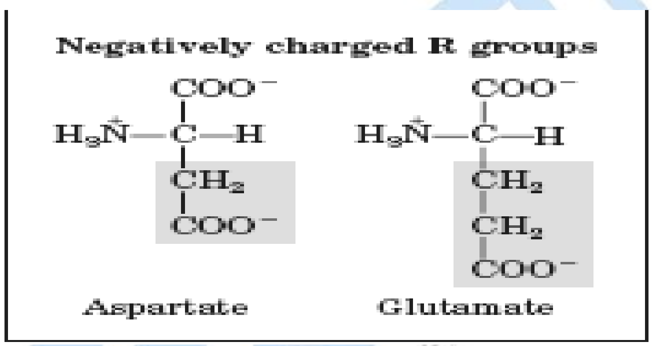
**Q.36 Write Structures of amino acids with uncharged R groups?**

**Ans.:**



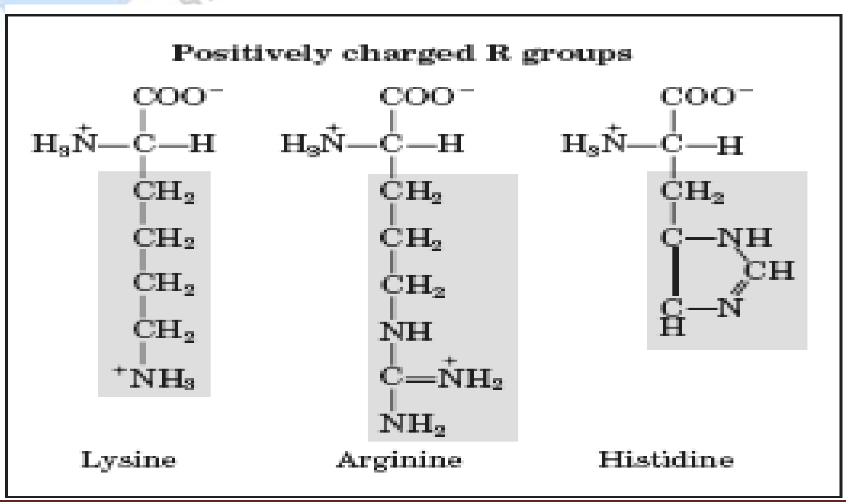

**Q.37 Write structures of amino acid with negatively charged R groups.**

**Ans.:**




**Q.38 Write structures of amino acid with positively charged R groups.**

**Ans.:**



**Q.39 What is peptide bond?**

**Ans.:** Polypeptides are linear polymers composed of amino acids linked together by peptide bonds. Peptide bonds are amide linkages formed when unshared electron pair & α - amino nitrogen atom of one amino acid attacks α – carboxyl carbon of another amino acid, has C – N bond with partial double bond character that gives rigid planar configuration. Rotation is permitted only about N – Cα and Cα – C bond. The bond angles labelled Ø for N – Cα & ψ for Cα – C bond are used as symbols.

**Q.40 Write in detail about Primary, Secondary tertiary and Quaternary structure.**

**Ans.:** Proteins have four levels of structural organisation.

**(a) Primary Structure:** Primary Structure of polypeptide is its amino acid sequence and amino acids are linked with peptide bonds. Amino acid sequence is specified by genetic information.

**(b) Secondary Structure:** As the poly peptide chain fold it forms certain localized arrangement with adjacent amino acids which constitute secondary structure. The most commonly types of Secondary Structure are ;

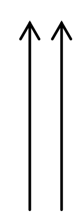
**α –helix**

***β* – Pleated sheets**

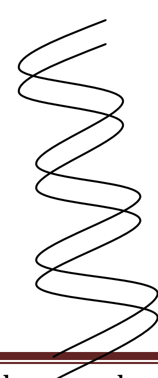
**α –helix:** rigid, rod like structure. When a poly peptide chain twists into right handed helical conformation hydrogen bond form between the N-H group of each amino acid and carboxyl group of amino acid, 4 residues away.

***β* –Pleated sheets:** form when two or more poly peptides chain segment line up side by side. Each individual segment refereed to as *β* strand and is stabilized by hydrogen bonds that form between the poly peptide back bone N-H and carboxyl group of adjacent chains.

Anti parallel *β* Sheets



Parallel *β* Sheets



α – helix

**(c) Tertiary Structure :** Unique three dimensional conformations that globular proteins assumes as a consequence of various interactions like hydrophobic interactions, electrostatic interactions, hydrogen bonds, covalent bond between the side chains of primary structure.

**(d) Quaternary Structure:** Proteins that consist of two or more poly peptide chains or subunits are said to have quaternary structure. Poly peptide subunits are held together by non-covalent interactions e.g.; collagen which is extra cellular matrix protein.

**Q.41 Write short note on organic acids. Explain any one.**

**Ans.:** Organic acid is an organic compound with acidic properties. Most common organic acid are the carboxylic acids. Organic acids are weak acids and do not dissociate completely in water.

(1) Acetic Acid (2) Formic Acid

(3) Citric Acid (4) Oxalic Acid

**Citric Acid:** It is hydroxy tribasic and occurs in citrus fruits like lemon and orange. Lemon juice contains 7-10 % citric acid. It is white crystalline solid exist as monohydrate & has strong acid test. It has following important uses;

**(1)** Used as mordant in dye industry.

**(2)** Its magnesium salt as laxative, ferric ammonic citrate in case iron deficiency & sodium citrate in baby powder milk.

**(3)** In preparation of Benedicts solution.

**Preparation**

(1) $C_{12}H_{22}O_{11} + H_2O \xrightarrow[\text{Oxidation}]{\text{Air}}$ $CH_2COOH$
Sucrose
| 
$C(OH)COOH$
|
$CH_2COOH$
Citric acid

(2) $\begin{array}{c} CH_2OH \\ \downarrow \\ CHOH \\ \downarrow \\ CH_2OH \end{array} \xrightarrow{2HCl} \begin{array}{c} CH_2Cl \\ \downarrow \\ CHOH \\ \downarrow \\ CH_2Cl \end{array} \xrightarrow[H_2CrO_4]{} $ Oxidation ] inter mediate $\xrightarrow{H_3O^+}$ Citric Acid

Glycerol                                                    Citric Acid

Reactions: (1) Citric Acid

$\downarrow H_2S_2O_7, \Delta$

Acetone di carboxylic Acid

$\downarrow \rightarrow CO_2$

Aceto acetic acid

$\downarrow \rightarrow CO_2$

Acetone

**(2) Complex for motion:** Alkaline solution of citric acid & copper sulphate solution in presence of sodium carbonate forms deep blue colored water soluble complex known as Benedict solution & is used to test aldehydes & reducing sugars.

**Q.42 Give example of Nitrogenous base.**

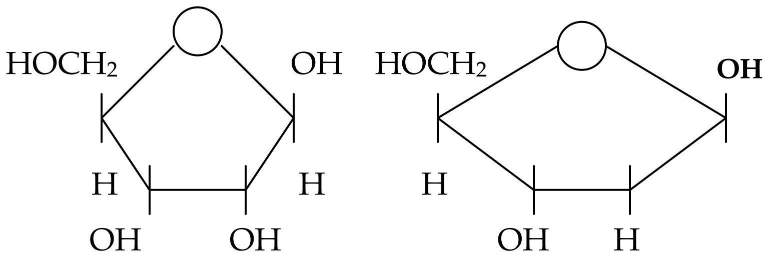
**Ans.:** (a) Purines: - Adenine & Guanine

(b) Pyrimidines : Cytosine ,Uracil, Thymine

**Q.43 Write structure of ribose and deoxyribose Sugar?**

**Ans.:**

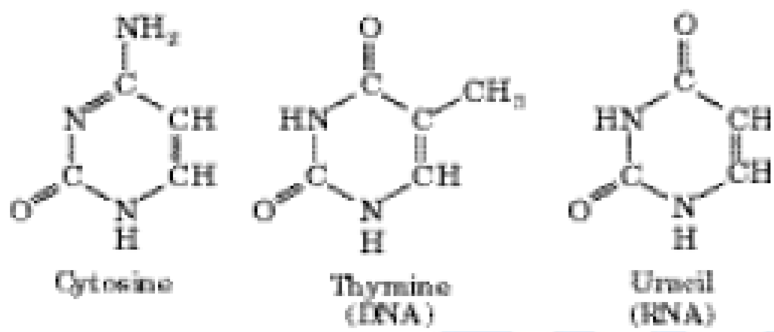
5′




$\beta$ – D – ribose $\beta$ – D – 2 deoxy ribose

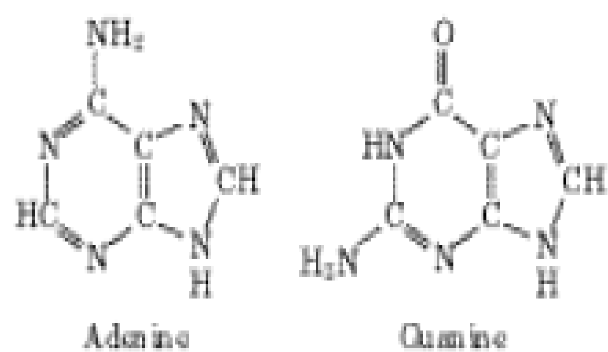
**Q.44 Give structure of Pyrimidine bases.**

**Ans.:**




**Q.45 Give structure of Purine bases.**

**Ans.:**




**Q.46 Write Hydrolytic products of nucleon acid.**

**Ans.:** $NH_3$ $BO(OH)_2$

Nucleotides

1150

Enzymes(nucleases) AqNH$_3$ Decreasing Nucleic Acid

175ºC Molecular

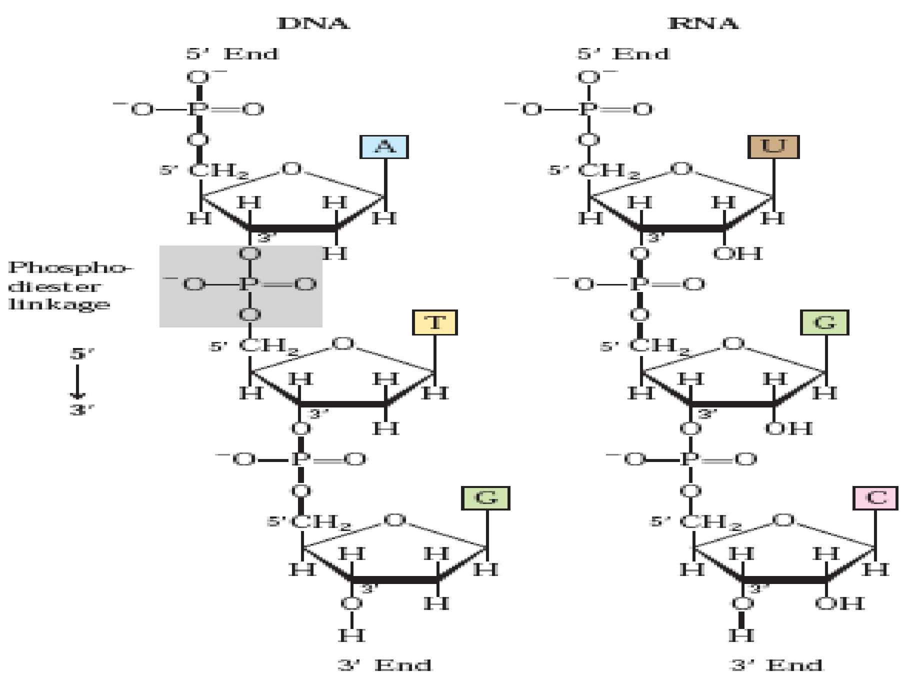
Wt MgO in SOI$^4$

Nucleosides + $H_3PO_4$ Heat

Heat with Inorganic Acid

Sugar + Purines + Pyrimidines

**Q.47 Give DNA and RNA structure showing phosphodiester bond.**




**Q.48 Which is insoluble RNA.**

(a) rRNA (b) tRNA

(c) mRNA (d) None **Ans.: (a)**

**Q.49 Which is known as template RNA.**

(a) tRNA (b) mRNA

(c) rRNA (d) None **Ans.: (b)**

**Q.50 Which is Soluble RNA.**

(a) mRNA (b) tRNA

(c) rRNA (d) All **Ans.: (b)**

**Q.51 Differentiate between Deoxyribonucleic (DNA) and ribonucleic acid (RNA).**

**Ans.:**

| S. No. | DNA | RNA |
|---|---|---|
| 1 | Found mainly in chromatin of cell nucleus. | Most RNA is present in cell cytoplasm & little in nucleus. |
| 2 | Never present in free state in cytoplasm. | May be present in free state. |
| 3 | Normally double stranded and rarely single stranded. | Single stranded and rarely double stranded. |
| 4 | Sugar moiety in DNA is 2′-deoxy ribose which contain a hydrogen atom at C -2. | Sugar moiety in RNA is ribose which contains 2′- hydroxyl group. |
| 5 | Nitrogenous bases are Adenine, Guanine, Cytosine and Thymine. | Common Nitrogenous base are Adenine, Guanine, Cytosine and Uracil. |
| 6 | The base ratio (A/T and G/C) are necessarily around one. | It need not have complementary base ratio. |
| 7 | DNA acts as template for its Synthesis. | RNA doesn't replicate. |
| 8 | DNA is usual genetic material. | RNA is genetic material of some viruses only. |
| 9 | During base pairing, Adenine pairs with Thymine and Guanine with Cytosine. | In case of pairing, Adenine Pairs with Uracil and Guanine with Cytosine. |

**Q.52 Which of following statement is not true for Lipids?**

(a) Esters of Glycerol and Fatty Acids.

(b) Hydrophobic in nature.

(c) Insoluble or Poorly Soluble in Water.

(d) None **Ans.: (d)**

**Q.53 Write four general functions of biological Lipids.**

**Ans.:** (1) They serve as storage form of metabolic fuel.

(2) They serve as transport form of metabolic fuel.

(3) They provide structural components of membranes.

(4) They have protective functions is bacteria, plants, insects and vertebrates serving as a part of the outer coating between the body of organism and the environment.

**Q.54 What do you understand by Triacylglycerols?**

**Ans.:** Triacylglycerols are triesters of fatty acids and glycerol, general formula can be given by.

$$H_2C - O - C - R_1$$

$$|$$

$$H - C - O - C - R_2$$

$$|$$

$$H_2C - O - C - R_3$$

They are non polar, hydrophobic in nature and major form of stored lipid. Because triacylglycerols have no charge they are some times referred to as neutral fats. Most triacylglycerol molecules contain fatty acids of varying, lengths which may be unsaturated, saturated or combination of both.. Fats which are solid at room temperature contain large proportion of saturated fatty acids. Oils are liquid at room temperature contain a large proportion of unsaturated fatty acids. If fats are hydrolyzed with alkali such as NaOH or KOH, soap is produced and process is called saponification.

**Q.55 What are Steroids and Eicosanoids.**

**Ans.:** Steroids are complex derivatives of tri-terpenes. Each type of steroid composed of four fused rings called steroid nucleus. Sterol is class of steroids characterized by hydroxyl group at C-3. Cholesterol, an important molecule in animals is example of sterol. It is and essential component in animal cell membranes. It acts as precursor for biosynthesis of all steroid hormones, vitamin D & bile salts. Sterol that is common to plants is stigma sterol and campesterol.

Eicosanoids originated from 20 carbon poly unsaturated fatty acids (eicosanoic acids), particularly arachidonic acid. It is includes Prostaglandins, thrombaxane and leukotrienes. They are potent hormones and act locally instead of being transported in blood to act on cells in other tissues or organs.

**Q.56 How many carbon atoms are present in plasmatic acid.**

(a) 15 (b) 16

(c) 14 (d) None **Ans.: (a)**

**Q.57 General Formula for Fatty acid (Saturated).**

(a) $CH_3 (CH_2)n - COOH$ (b) $CH_3 (CH_2)n - (COOH)_2$

(c) $CH_3 COOH$ (d) None **Ans.: (a)**

**Q.58 Non – essential Fatty acids are synthesized form.**

(a) Acetic Acid (b) Acetyl Co – A

(c) Aceto Acetic Acid (d) All of above **Ans.: (b)**

**Q.59 Unsaturated fatty acids have**

(a) Presence of double bonds (b) Presence of Methyl group

(c) sp hybridization (d) All of above **Ans.: (a)**

**Q.60 Essential fatty acid:**

(A) Linoleic acid

(B) Linolenic acid

(C) Arachidonic acid

(D) All these

**Ans.: (D) All these**

Q.61 The physical properties of cholesterol are best described as

a. polar, charged.

b. polar, uncharged.

c. nonpolar.

d. amphipathic, charged.

e. amphipathic, uncharged

**Ans.: e. amphipathic, uncharged**

**Q.62 A characteristic common to all lipids is**

a). that they contain long chains of C-H bonds.

b). that they are insoluble in water.
c). that they have a glycerol backbone.
d). All of these are characteristics of all lipids.
**Ans.: b) that they are insoluble in water.**

**Q.63 A characteristic of unsaturated fats is that they**
A. denature as they cool.
B. are made up of glucose and fructose.
C. are made up of amino acids and glycerol.
D. have double bonds in their carbon chains.

**Ans.: D) have double bonds in their carbon chains.**

**Q.64 Which of the following are components of a phospholipid?**
A. cholesterol, glycerol, fatty acids
B. fatty acids, phosphate group, glycerol
C.glycerol, amino acids, phosphate group
D. phosphate group, cholesterol, monosaccharides

**Ans.: B. fatty acids, phosphate group, glycerol**

**Q.65 Compared to saturated fats, unsaturated fats contain less**
A. oxygen.
B. glycerol.
C. hydrogen.
D. fatty acids.

**Ans.: C. hydrogen**

**Q.66 A lipid molecule is produced when**
A. fatty acids bond to glycerol.
B. amino acids bond to glycerol.
C. monosaccharides bond to glycogen.
D.dehydration occurs between fatty acids and glycogen.

**Ans.: fatty acids bond to glycerol.**

**Q.67 Lipids are composed of**
A. nucleotides.
B. amino acids.
C. monosaccharides.
D. glycerol and fatty acids.

**Ans.: D. glycerol and fatty acids.**

**Q.68 What are phospholipids? Write about different types of phospholipids.**

**Ans.:** Phospholipids are amphipathic molecules abundantly found in plasma membrane. There are two types of phospholipids:

(a) Phosphoglycerides (b) Sphingo phospholipids

**(A) Phosphoglycerides or Glycero phospholipids:** Are molecules that contain glycerol, fatty acids, Phophate and an alcohol (e. g. Choline) Phosphoglycerides are most numerous phospholipids molecules found in cell membranes. The simplest phophoglyceride is phosphatidic acid composed of Glycerol-3 phosphate that is esterified with two fatty acids. Phosphoglyceride molecules are classified according to which alcohol becomes esterified to phosphate group for example if alcohol is choline, the molecule is called phosphatidylcholine and if serine called phosphatidylserine.

**(B) Sphingo phospholipids:** Contain long chain amino alcohol called Sphingosine instead of Glycerol. When amino group of Sphingosine is acylated with fatty acid, the product is ceramide which is structural parent of all Sphingolipids.

**Glycosphingo lipid:** In glycosphingolipid head group contains one or more sugars connected directly to – OH at C -1 of ceramide moiety.

**(1)** **Cerebroside:** Have single sugar linked to ceramide.

**(2)** **Globoside:** With two or more sugars.

**(3)** **Gangliosides:** A complex glycophospholipid that contain oligo saccharide as their polar head groups and one or more residues of N-acetyl neuraminic acid and sialic acid.

**Selected Sphingo lipid Storage Diseases:**

| S. No. | Name | Accumulating Sphingolipid | Symptom |
|---|---|---|---|
| 1 | Tay Sachs disease | Ganglioside | Blindness, mental retardation. |
| 2 | Gaucher's disease | Glucocerebroside | Livers and spleen enlargement, mental retardation. |

□ □ □

# Section-C

## Chapter-1

# Nucleus and Heredity

**Q.1 Okazaki fragments are also known as:**

(a) Leading Strand (b) Lagging Strand

(c) Both (d) None

**Ans.: (b) Lagging Strand**

**Q.2 Semi Conservative mechanisms was demonstrated by:**

(a) Meselson & Stahl (b) Watson & Crick

(c) Both (d) None

**Ans.: (a) Meselson & Stahl**

**Q.3 Nuclear pore complex contain:**

(a) Column Component (b) Luminal Component

(c) Annular Component (d) All of above

**Ans.: (d) All of above**

**Q.4 Gene is -**

(a) Nucleoside sequence (b) Chromosome

(c) DNA (d) Nucleotide sequence

**Ans.: (d) Nucleotide sequence**

**Q.5 RNP stands for:**

(a) Ribo Nuclear Protein (b) Ribosome Nuclear Protein

(c) Ribo Nucleolar Protein (d) None

**Ans.: (a) Ribo Nuclear Protein**

**Q.6 3′→ 5′ Proofreading is required for:**

(a) Replication Fidelity (b) Replication error

(c) Both (d) None

**Ans.: Replication Fidelity**

**Q.7 Eukaryotic RNA Polymerase I is present in:**

(a) Nucleolus (b) Nucleus

(c) Cytoplasm (d) Mitochondria

**Ans.: (a) Nucleolus**

**Q.8 UREs are known as:**

(a) Upstream Regulating Elements

(b) Upstream Regulatory Elements

(c) Both

(d) None

**Ans.: (b) Upstream Regulatory Elements**

**Q.9 Polysomes are:**

(a) Polyribosome (b) Poly Nucleosomes

(c) Both (d) None

**Ans.: (a) Polyribosome**

**Q.10 Ribosome binding site is known as:**

(a) TATA BOX (b) Shine – Dalgarno Sequence

(c) UREs (d) None

**Ans.: (b) Shine – Dalgarno Sequence**

**Q.11 How many initiation factors are present in Prokaryotes?**

(a) 1 (b) 2

(c) 3 (d) 4

**Ans.: (c) 3**

**Q.12 Which of the following is Eukaryotic releasing factor (RF).**

(a) e RF – (a) (b) e RF – ATP

(c) e RF – G (d) e RF

**Ans.: (d) e RF**

**Q.13 Translational Elongation is associated with:**

(a) Amino –acyl – tRNA delivery (b) Peptide bond formation

(c) Translocation (d) All of above

**Ans.: (d) All of above**

**Q.14 Which of the following is start codon:**

(a) AUG (b) GUG

(c) AAA (d) None

**Ans.: (a) AUG**

**Q.15 Which of the following is translocase:**

(a) (EF – G) (b) RF – 1

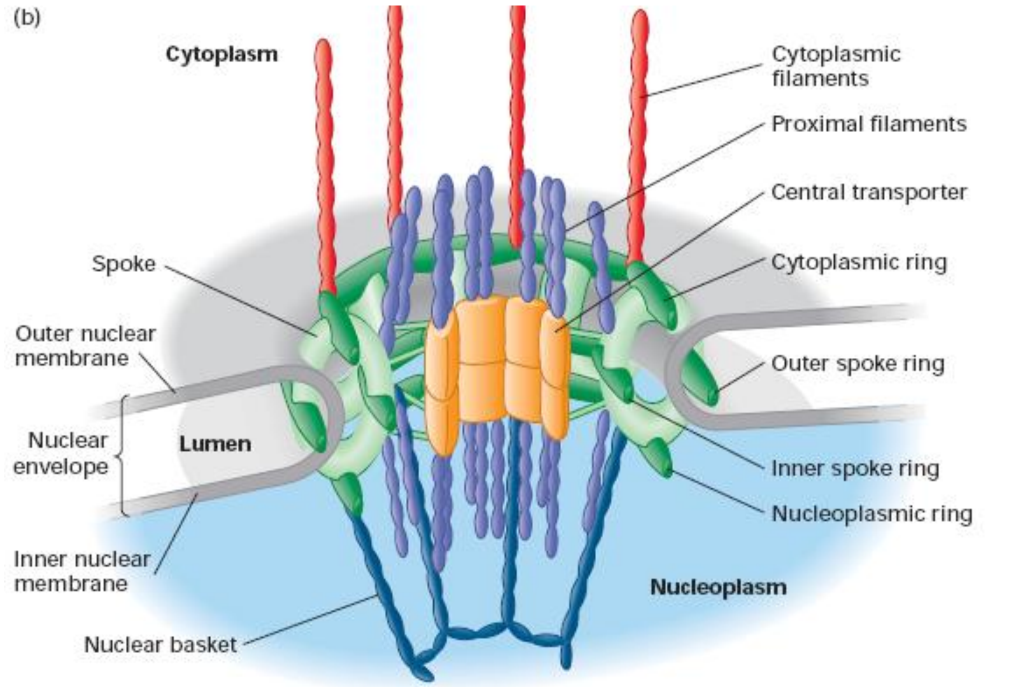
(c) EF – TU (d) EF – TS

**Ans.: (a) (EF – G)**

**Q.16 Write short note on Nuclear membrane Y Nucleopore complex.**

**Ans.: a)** Structure: Nuclear envelop encloses the DNA & defines the nuclear compartment. It is formed of two membranes. The inner membrane contains specific proteins that act as binding sites for nuclear lamina that supports it. The inner membrane is surrounded by outer nuclear membranes which closely resemble outer membrane of Endoplasmic reticulum. In between outer and inner nuclear membrane space present is called perinuclear space Nuclear envelop in all Eukaryotes is perforated by nuclear pores. Each pore is formed by large elaborate structure known as nuclear pore complex.

Each pore complex contains one or more open aqueous channels through which water soluble molecules that are smaller in size can diffuse.




In cross section the nuclear pore complex appears and composed of:

(1) Column component which forms the bulk of pore wall.

(2) Annular component which extend spokes toward centre of the pore.

(3) Luminal component which is formal by large trans membrane glycoprotein that is thought to help anchor the complex to nuclear membrane. On nuclear side the fibrils converge to form cagé like structure.

Protein & RNA molecules bind to specific receptor protein located in pore complexes are actively transported across the nuclear envelop through complexes.

**Q.17 Describe Packaging of DNA?**

**Ans.:** Gene is defined as nucleotide sequence in a DNA molecule that acts as functional unit for production of an RNA molecule. A chromosome formed form single enormously long DNA molecule that contain set of many genes.

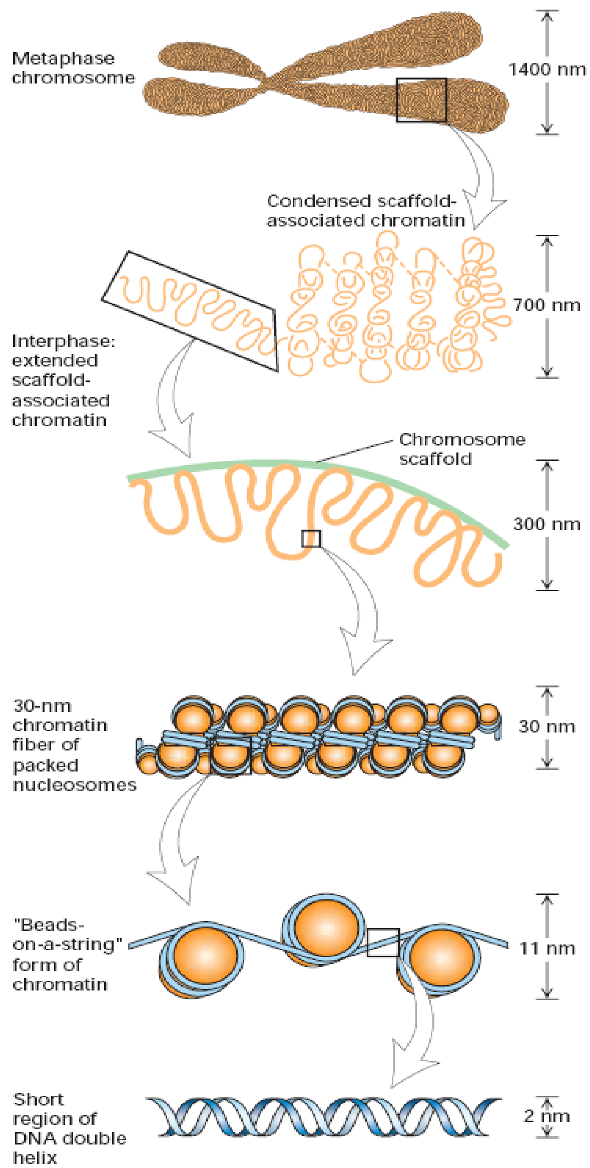
Eukaryotic chromosomes contain a long linear DNA molecule which must be packaged into nuclear. The name chromatin is given to highly ordered DNA protein complex which makes up Eukaryotic chromosomes. The chromatin structure serves to package & organize chromosomal DNA & is able to alter its level of packing at different stages of cell.

The major components of chromatin are histones small basic proteins which bind tightly to DNA. There are four families of core histones, H2A, H2B, H3 H4 & H1 which has some different properties & distinct role.

Nucleosome core is the basic unit of chromosomes structure, consisting of protein octamer containing two each of core histones with 146 bp of DNA wrapped around it. A single molecule of H1 organizes DNA between nucleosomes. A nucleosome core plus H1 is known as chromtosome.

Chromatin is organized into larger structure, known as 30nm fibre or Solenoid, thought to consist of a left handed helix of nucleosome with approximately 6 nucleosomes per helical turn. Most chromatin exists in this form.

On the higher order structure chromosomal DNA is organized into loops of up to 100 Kb in form of 30mm fiber. The over all structure save what resembles that of the organizational domains of prokaryotic DNA.




Three-Dimensional Packing of Nuclear Chromosomes

**Q. 18 Comment 'DNA as a genetic material '.**

**Ans.:** DNA is found to be the genetic material in almost all living beings except some plant viruses.

Evidences of DNA as genetic material.

**(1) Bacteria Transformation:** By Frederick Griffith provided first clear evidence that DNA is hereditary material while working with – Pneumonia causing bacteria. He conducted following set of experiments.

(1) Virulent strain → culture → inject mice → Death
↓
Virus Recovered

(2) Non Virulent strain → culture → inject mice → Lives
↓
No Virus Recovered

(3) Virulent strain → Heat Killed → inject mice → Lives
↓
No Virus Recovered

(4) Virulent strain (Heat killed) + non virulent → inject mice → Death
↓
Virus Recovered

**Conclusion:** presence of heat killed Virulent strain has caused transformation of nonvirulent bacteria into Virulent called bacterial transformation.

**(2)** Three Scientists Avery Macleod & Mc. Cartey recognized the principle for converting non virulent to virulent and found it to be DNA.

**(3)** Lederberg and Tatum showed that conjugation results in transfer of genetic material (DNA) from one to other. During conjugation cytoplasmic bridge is formed between conjugated bacteria & DNA transferred was found to be vary with period of conjugation. Also, length of DNA & amount of genetic information transferred are directly related.

**(4)** Hershey along with Luria and Dulbruck discovered phage lytic cycle & demonstrate that DNA enters the host cell and act as hereditary or genetic material.

Following above experiments demonstrate that DNA is the genetic material and is responsible for careering genetic information.

**Q.19 Describe DNA Replication in Prokaryotes and Eukaryotes.**

**Ans.:** Transmission of chromosomal DNA from generation to generation is crucial to cell propagation. This can only be achieved when chromosomal DNA is accurately replicated, providing two copies of the enter genome for distribution in each daughter cell.

**(A)** **Semi Conservative Replication:** If the two strands of parental double helix of DNA separated, the base sequence of each parental strand could serve as template for synthesis of new, complementary producing two identical progeny double helices. This process is called Semi Conservative Replication because the parental double helix is half conserved each parental strand is remaining intact.

**(B) Unidirectional and Bidirectional DNA Replication:** all known DNA molecules, with only few exceptions replicate as circles & hence initiate within the helix. DNA replication doesn't start at random locations but at particular sites called origins of DNA replication. A DNA whose replication starts from an origin and proceeds bidirectionally or unidirectionally to terminals site is called replicon. In each replicon replication is continuous from origin to terminus & associated with movement of replication point called Replication fork. In bidirectional replication both ends of replication fork are moving. Where as in unidirectional replication one of two ends of replication end remains stationary and other end serve as replication fork and moves with replication. An example of unidirectional replication is replication of mitochondrial DNA.

**(C) Enzymes for DNA Replication:** Different prokaryotic and Eukaryotic cells have been found to contain three kinds of nuclear enzymes that act on DNA namely nucleases, polymerases and ligases.

**(I) Nuclease Enzyme:** The Nuclease Enzyme act to hydrolyze or break down a polynucleotide chain into its component nucleotides. A polynucleotide is held together by 3′, 5 phosphodeister bond and nuclease enzyme will attack either the 3′ or 5′ end of linkage.

**(a) Exonuclease Enzyme:** Exonuclease enzyme which begins attack at 3′ OH and 5′ P end of polynucleotide is called exonuclease.

**(b) Endonuclease Enzyme:** Endonuclease enzyme also attacks one of the two sides of phophodiester linkages but react only with those bonds that occur within the interior of Polynucleotide chain.

**(II) Polymerase or replicase Enzyme:** It catalyses the formation of a polymer. A polymerase enzyme is called replicase enzyme, brings about chromosome replication.

**Prokaryotic DNA polymerases:** Three different DNA polymerases are known in *E. coli* and other prokaryotes of which DNA polymerase I and II are mean for DNA repair DNA Pol III for actual DNA replication.

**(a) DNA polymerase I: i**solated by Arthur Kormberg and known is Kornberg enzyme. This enzyme has template site, primer site at → 3′ cleavages or Exonuclease site. DNA Pol is involved in removing RNA primers form Okazaki fragment and filling gap due to its 5′ → 3′

polymerase capacity. Both polymerization & exonuclease activity DNA polymerase I is called as proof reading or editing function.

**(b)** **DNA Pol II:** It is DNA repair enzyme & brings about growth in $5' \rightarrow 3'$ direction using $3'$ – OH groups.

**(c)** **DNA Pol III:** Plays essential role in DNA replication. It is multimeric enzyme having the Subunits, all having different functions.

**(d)** **DNA Ligases:** Capable of catalyzing phosphodiester bond formation between 3′ OH and 5′ P group of a nick of DNA. This is created by endonuclease enzyme there by restoring and DNA duplex.

**(III)** **RNA Primers in DNA replication:** DNA polymerase cannot initiate synthesis of DNA without availabity of a primer strand. Short RNA oligonucleotide segments called RNA primers have to be synthesized by DNA primase. The primers are about 10 nucleotides. In bacteria two different enzymes are known to synthesize primer RNA oligonucleotides – RNA polymerase (on leading strand) & DNA primase on lagging strand.

**(D)** **Proteins involved in opening of DNA helix :**

**(I)** **DNA helicases:** Are ATP dependent unwinding enzymes which promote separation of the two parental strands and establish of replication fork unwinding of template DNA helix. At replication fork two DNA helicases act, one running along the leading strand and other along lagging strand.

**(II)** **Single strand DNA binding proteins:** Behind the replication fork the Single DNA strands are prevented from rewinding about one another (or forming double stranded hair pin loops in each Single Strands) by action of Single Stranded Binding Proteins. SSB proteins bind to exposed DNA strands without covering bases which there fore remain available for templating process.

**(III)** **DNA GYRASE:** The action of helicase introduces a positive Super coil into Duplex DNA ahead of replication fork. Enzyme called topoisomerase relax the super coil by attaching to transiently super coil Duplex nicking one of the strand and rotating it through the unbroked strand, the nick is then resealed.

**Topoisomerase I :** cause single strand break or nick which allow two sections of DNA helix on either side of nick to rotate freely relative to each other using phosphodiester bond in strand opposite the nick.

**Topoisomerase II:** Forms covalent bond to both strands of DNA helix at the same time making transient double strand break in helix.

**Replication of DNA in Prokaryotes:**

**(1) Initiation of DNA replication :** Comprising three steps :

(i) Recognition of the origin. (0)

(ii) Opening of DNA duplex to generate a region of single stranded DNA.

(iii) Capture of Dna B protein (5′→ 3′ helicase)

Dna – A – ATP complex binds at 9bp inverted repeat regions of ori. C of E coli and provides opening of DNA duplex in a region of 3 direct repeats of 13 bp sequence. The opening occurs form 13 mer left wards and requires negatively super coiled DNA and HU proteins. Dna B is transferred to exposed single stranded DNA & cause unwinding of DNA in presence of ATP, SSB protein and DNA gyrase. This result in unwinding of DNA duplex & replication from origin proceeds in both directions.

**(2) Elongation of DNA chain:** This step requires presence of following enzymes.

(i) Helicase

(ii) Primase

(iii) DNA polymerase Holo enzyme

(iv) SSB Protein

(v) RNAS H

(vi) DNA polymerase I

(vii) Ligase

(1) Helicases travel in 5′ → 3′ direction it generates a replication fork by opening DNA duplex.

(2) DNA strand having heliase become lagging strand .DNA primase associates with helicase forming primosome which synthesize multiple primers for lagging strand & single RNA primer for leading strand.

(3) For synthesis of lagging strand, DNA pol III has to work on some strand to which DNA B helicase is bond but it travels in opposite direction, helicase, primase and DNA pol III work together in strand elongation.

Primase is taken up from solution and is activated by helicase to synthesise a RNA Primer strand & utilized for synthesis of precursor okazaki fragments. On completion of okazaki fragments the RNA primer are excised by DNA pol I which then fills the gap .DNA ligase forms phosphodiester bond. That links the free 3′ end of primer replacement of 5′end of okazaki fragments.

In bidirectional DNA replication the leading strand is primed once on each of parental strand. RNA primer of leading strand is synthesized by RNA polymerase enzyme DNA pol III cause elongation of leading strand & finally DNA pol I and ligase enzyme give final to touch to leading strand.

**Eukaryotic DNA polymerase:** Eukaryotes found to contain following 5 types of Polymerase.

- **(i) DNA Pol α :** Cytoplasmic polymerase
- **(ii) DNA Pol β :** Nuclear polymerase
- **(iii) DNA Pol Y :** Mitochondrial polymerase.
- **(iv) DNA Pol δ :** Found in mammalian cell and is PCNA dependent for DNA synthesis possessively.
- **(v) DNA Pol ξ :** Found in budding yeast & hela mammalian cell.

Eukaryotic DNA replication requires two different DNA polymerase enzymes namely DNA Pol α &DNA Pol δ. DNA Pol δ synthesizes the DNA on leading strand where as DNA polymerase α synthesizes the DNA on lagging strand. Several other factors are also involved in eukaryotic DNA replication.

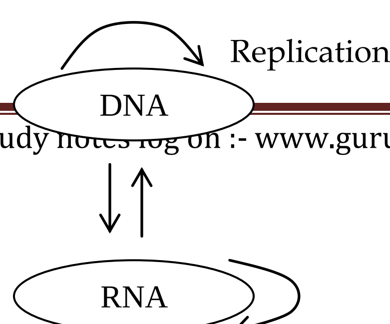
Before onset of DNA synthesis there is presynthelic stage 8 – 10 Minutes duration for formation of unwound DNA Duplex. This step needs only 3 purified proteins, namely T – antigen, RF – A & Topoisomerase I & II .T – antigen using its DNA binding domain forms a multi subunit complex with site in presser of AIP & cause local unwinding.

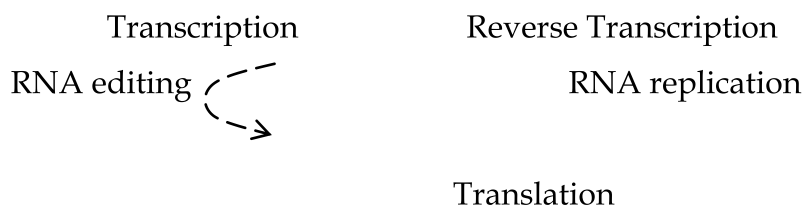
More extensive duplex unwinding occurs due to association of RF – A & Topoisomerase with help of helicase component help in unwinding of DNA by altering topology of DNA at replication fork. RF – A or SSB proteins bind to unwound single stranded DNA. The primer RNA synthesis is formed by primase which is tightly associated with DNA polymerase α. DNA Pol α helps in synthesis of okazaki fragment in 5′ – 3′ direction. RF – C & PCNA help in switching DNA polymerase so that Pol α is replaced by Pol δ which is then continuously synthesized on the leading strand. Another okazaki fragment is then synthesized from replication fork on lagging strand by Pol α-primase complex & this step is repeated again and again till entire DNA molecules is covered.

RNA primers are removed and gaps all filled as in prokaryotic DNA replication. The small size of eukaryotic lagging strand fragments appears to reflect the amount of DNA wound from each nucleosome as fork progresses. In addition to doubling the DNA, the histone content of cell is also doubled during S phase.

**Q.20 What is "CENTRAL DOGMA"?**

**Ans.:** There is unidirectional flow of genetic information form DNA through RNA to Protein is that is DNA makes RNA which makes protein.



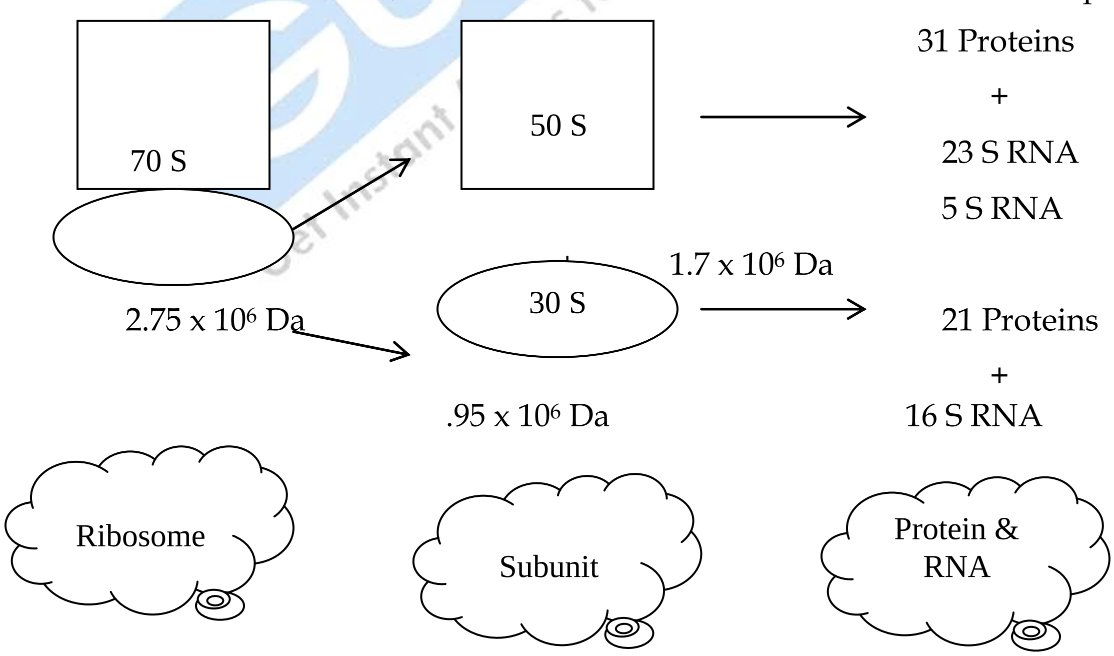



The flow of genetic information

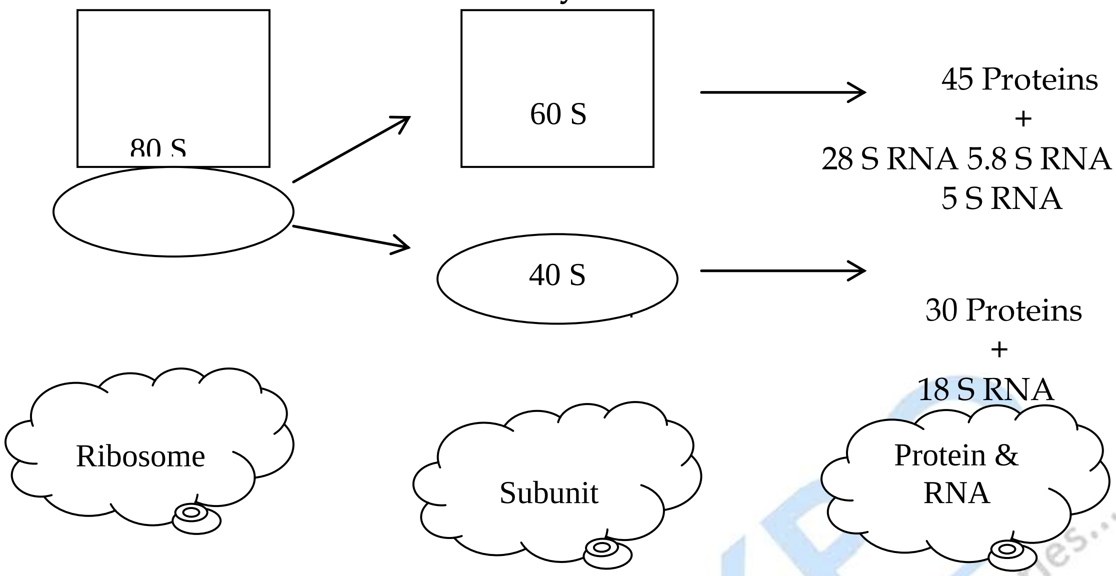
**Q. 21 Give Detail account an Prokaryotic & Eukaryotic Ribosome's.**

**Ans.: Prokaryotic Ribosomes:** Ribosome are complexes of r RNA and specific ribosome proteins and other large RNPs are the machines the cell uses to carry out translation. The E coli 70 S ribosome is formed from large 50 S and small 30 S diff proteins and one each of 235 and 5S r RNA. The small subunit contains 16 S r RNA molecule and 21 different proteins.

**Eukaryotic Ribosome :** Are larger and complex then their prokaryotic counterparts but carry out the same role. The complete mammalian 80s ribosome is composed of one large 60 S subunit some small 40 S. subunit. The 40 S subunit contains 18 S r RNA molecule and about 3 destruct proteins. The 60 S subunit contain one 5 S r RNA, one 5 – 8 S r RNA one 28 S r RNA and about 45 proteins.



**Prokaryotic Ribose**




**Eukaryotic Ribosome**

**Q. 22 Write short note on mechanism of protein syntheses?**

**Ans.:** There are three stages of protein synthesis;

**(1)** **Initiation:** The assembly of ribosome on mRNA.

**(2)** **Elongation:** Repeated cycles of amino acid delivery, peptide bond formation and movement a long mRNA (translocation).

**(3)** **Termination:** The release of polypeptide chain.

**Initiation:** In prokaryotes, initiation requires the large and small ribosome subunit the mRNA, the initiator t RNA, three ignition factors ($IF_s$) and GTP, $IF_1$ and $IF_3$ bind to 30 S subunit and prevents the large subunit binding. $IF_2$ + GTP can their bind & will help initiator t RNA to bind later. This small subunit complex now attach to mRNA via its ribosome binding sites. The initiator t RNA can then base pair with AUG initiation colon which release $IF_3$ thus creating 30 S initiation complex the large subunit then binds, displacing $IF_1$ and $IF_2$ + GDP giving 70 S initiation complex which is fully assembled ribosome at corrected position on mRNA.

**Elongation:** Involves the three factors (EFs), EF – Tu, EF – Ts & EF – G, GTP charged t RNA and 70 S ignition complexes. It takes place in three steps.

(1) A charge t RNA is delivered as complex with EF – Tu and GTP. The GTP is hydrolyzed and EF – Tu GDP is released which can be reused with the help of EF – Ts & GTP.

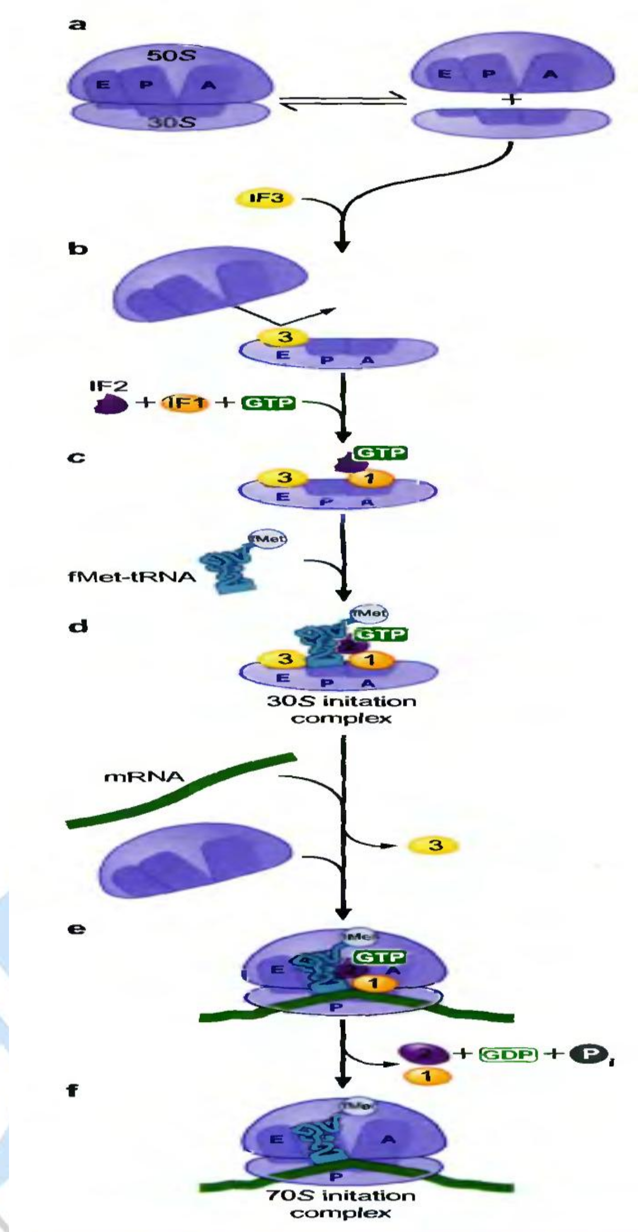
(2) Peptides transferees make peptide bond by joining the two adjacent amino acids without the input of more energy.

(3) Translocase (EF –G), with energy form GTP moves the ribosome one colon along the mRNA, ejecting the uncharged t RNA and transferring the growing peptide chain to P sites.

**Termination:** Release factors ($RF_1$ or $RF_2$) recognize stop codons & helped by $RF_3$ make peptides transferase join the polypeptide chain to water molecules, thus releasing it. Ribosome release factor helps to dissociate the ribosome subunits form the mRNA.

Most of the differences in mechanism of protein syntheses between prokaryotes and eukaryotes occur in initiation stage however, eukaryotes have just one release factor (eRF). The eukaryotic initiator t RNA doesn't become N – formatted as in prokaryotes.

The eukaryotic 40 S ribosome subunit complex binds to 5' cap region of the mRNA complex and moves along it looking for an AUG start colon.




Translation summary in prokaryotes.

**Initiation:** This major point of difference between prokaryotic & eukaryotic protein synthesis there being at least nine eIFs involved functionally this factor can be groups they either bind to ribosome subunits or to the m RNA deliver the initiator t RNA or displace other factors. In contrast to the event in prokaryotes initiation involves the initiator t RNA biding to 40 S subunit before it can bind to mRNA phophorytation of $eIF_2$ which delivers the initiator tRNA, is an important control point.

**Elongation:** This stage of protein Synthesis is essentially identical to that described for prokaryotes. The factors EF – Tu, EF – Ts & EF – G have direct eukaryotic equivalents called eEFl α, eEFl $\beta$, γ & eEF – 2 respectively which carry out the same roles.

**Termination:** Eukaryotes use only one release factor (eRF), which requires GTP, for termination of protein synthesis. If can recognize all there stop colons.

**Translational Control:** In prokaryotes the level of translation of different citrons can be affected by;

**(1)** Binding of short antisense molecules.

**(2)** Relative stability to nuclease of parts of polycistronic mRNA.

**(3)** Binding of proteins that prevent ribosome access.

In Eukaryotic protein binding can also mask the mRNA, prevent translation & repeats of sequence 5′ AUUUA – 3′ can make mRNA unstable and less frequently translated.

**Protein Targeting :** The signal sequence of secreted proteins causes the translating ribosome to bind factors that make the ribosome dock with membrane and transfer the protein through the membrane as it is synthesized usually the signal sequence is then cleaved off by signal peptidase.

**Protein modification:** The most common alterations to nascent polypeptides all those of cleavage and chemical modification. Cleavage accurse to remove signal peptides to release mature fragments from poly proteins to remove internal peptides as well as trimming both N & C termini often Phosphorylation controls activity of protein.

**Protein degradation:** Damaged modified or inherently unstable proteins are marked for degradation by having multiple molecules of ubiquitin covalently attached. The ubiquitin ylated protein is then degraded by protease complex.

**Q. 23 Explain Mechanism of Transcription.**

**Ans.:** Transcription involves following three aspects:

(1) Enzymatic synthesis of RNA.

(2) Signals that determine at what point on DNA molecule transcription start & stop.

(3) The types of transcription product show they are converted to RNA molecules needed by all.

**(I)** **Enzymatic synthesis of RNA:** Following are the essential characteristics of synthesis of RNA.

(1) The precursor in synthesis of four ribonucleotide triphosphates ATP, GTP, CTP & UTP. On ribose portion of each dNTP there are two on groups – one each on 2′ & 3′ – carbonators.

(2) In polymerization reaction 3′ – OH group on one nucleotide reacts with 5′ – tri phosphate of a second nucleotide a pyrophosphate is removed and a phophodiester bond results.

(3) Sequence of base in RNA molecule is determined by base sequence of DNA. The DNA molecule being transcribed is double stranded, only one strand serve as template.

(4) RNA chain grows in 5′→ 3′ direction; that is nucleotides are added to 3′ OH end of growing chain. The RNA molecule is terminated by a 5′- tri phosphate at non growing end. The RNA molecule is autiparallel to DNA stand being copies. Once initiated RNA chains grow at rapid rate of 40 – 50 ntd per second.

(5) RNA polymerase in contrast with DNA polymerase is able to initiate chain growth that is no primer is needed.

(6) Only ribonucleoside 5′ tri phosphates participate in RNA synthesis & first base to be laid down in initiation event is a tri phosphate.

**Overall Requirements:**

**XTP** → First nucleotide at 5′ terminus of RNA chain.

**NMP** → Mono nucleotide in RNA chain.

**RNA – P** → RNA polymerase

**PPi** → Pyrophosphate released.

**$Mg^{+2}$** → required for polymerization.

**RNA polymerase Enzyme:** In prokaryotes single RNA polymerase is responsible for all kind of RNA's synthesis. It is one of the largest enzymes known. Consist of six subunit is (polypeptide chain) two identical alpha (α) and one chain each of ($\beta$), omega (ω) & sigma (σ) subunit. The complete RNA polymerase is termed as holo enzyme and represented as $\alpha_2 \beta\beta^1 \omega \sigma$ association of σ factors is not very firm. Sigma factor helps in recognition of start signals on DNA molecule and directs RNA polymerase in selecting the initiation sites one RNA molecule becomes 8-9 bases long σ factor dissociates & core enzyme brings about elongation of m RNA.

**(II) Binding of RNA polymerase to Promoter & Initiation:** Transcription doesn't progress along entire length of chromosome only some parts are transcribed also only one of two strand of DNA are transcribed this strand is called sense strand & the other strand is called antisense strand. RNA is synthesized in 5 → 3′ direction localized unwinding move along molecules followed by recoiling of the helix behind the nearly synthesized RNA. The region of sense strand of DNA which is transcribed into RNA is called coding region.

The first step in initiation is binding of RNA polymerase to DNA molecules. Binding occurs at particular sites → PROMOTERS which are specific sequences of 20 – 200 bases. Two special promoter regions have been identified:

**(1)** **Pribnow box:** Consensus sequence region of fine to ten bases preceding the coding region. Consensus sequence is **TATAATG.**

**(2)** **Hogness box :** In Eukaryotes the same region has the sequence :

**TATAAAT** Also known as **TATA BOX**. It is region in which double helix opens to form open promoter complex.

Another important region further upstream from **TATA BOX** is 30-35 bases form coding region called -35 sequence or recognition sequence. σ Subunit first binds to -35 sequences in a highly specific interaction and then, appropriate region some in contact with -10 sequence of pribnow box.

The open promoter complex has local unwinding of DNA helix. The base composition of sequence of pribnow box is A + T rich makes DNA strand to open.

**Elongation:** Once an open promoter complex has formed, RNA polymerase is ready to initiate RNA synthesis. RNA polymerase contains two nucleotides binding sits called initiation site and elongation site. The initiating nucleoside tri phosphate binds to enzyme in open promoter complex and forms hydrogen bond. The elongation site is then filled with

Nucleoside tri phosphate & the two nucleotides are joined together first base is released from initiation site and initiation is completed.

The elongation phase begins when polymerase releases the base & then moves along the DNA chain. After several nucleotides are added to growing chain RNA polymerase changes its structure and form stable ternary elongation complex. The core enzyme moves along the DNA binding nucleoside tri phosphate that can pair with next DNA base & open the DNA helix as it moves thus during elongation phase addition of 40 bases per second at 37°C takes place. The nearly synthesized RNA is released form its hydrogen bonds with DNA as helix reforms.

**Termination :** RNA synthesis termination occurs at specific base sequence in DNA molecule Termination region consist stein loop configuration or G + C rich region or sequence of A. T pairs that yield in RNA sequence 6 to 8 waits followed by adenine.

In fact there are two types of termination event those that depend only on DNA base sequence & those that require the presence of termination protein called shop.

**Eukaryotic Transcription:** For Eukaryotic transcription the regulatory DNA sequences for genes transcribed by each of three RNA polymerase differ.

**Initiation:** Various transcription factors are also involved in formation of transcription complex. Each RNA polymerase is believed to have its own set of transcriptions factors.

Transcription factors can be defined as proteins which are needed for initiation of transcription. They help in DNA binding of a RNA polymerase and constitute so called **Pre Initiation Complex.**

**(a) Formation of Transcriptosome:** A promoter sequence which is responsible for generic promoter. Initiation of transcription generic promoter by RNA polymerase II require following set of transcription factors :

(i) TF II D binds at TATA box.

(ii) The (i) step permits the association of TF II A & TF II B.

(iii) TF II B forms so called DB complex and RNA Polymerase II associates to promoter site.

(iv) RNA pol II is facilitated toward promoter TF II F to form transcription complex.

(v) Orderly addition of TF II E, TF II H and TF II j helps the initiation process.

**Elongation:** There are certain accessory proteins of transcription called elongation factors which over all enhance the activity of RNA polymerase II and lead to increase is the elongation rate. At least two such proteins are known.

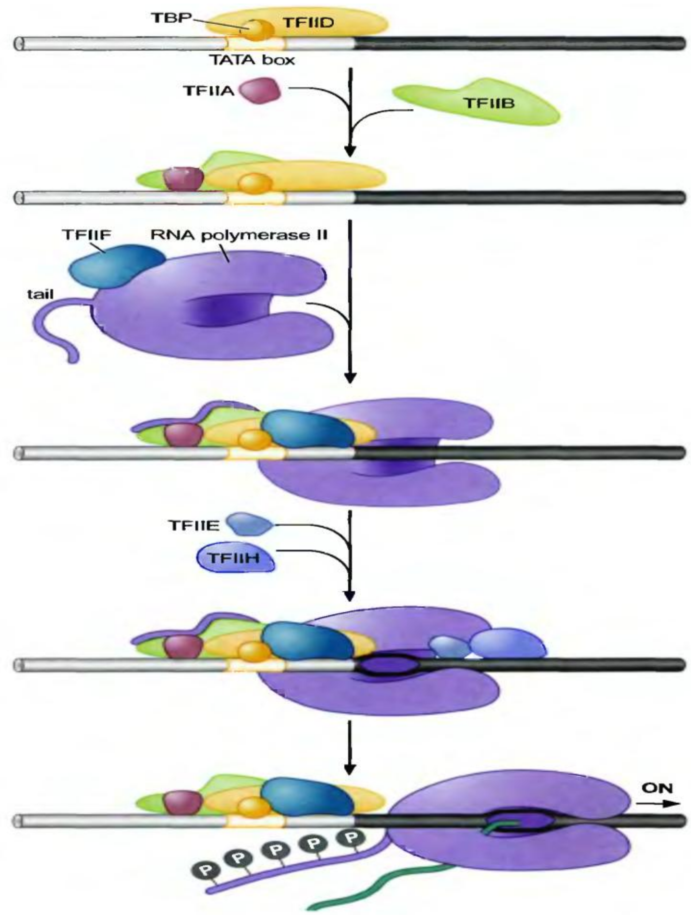
(i) TF II F accelerated RNA chain growth relatively uniformly in concord with RNA Polymerase II.

(ii) The TF II S helps in elongation of RNA chain by unburdening the obstruction in path of such elongation. TF II S is known to act: by first causing hydrolytic cleavage at 3′ end of RNA chain there by helping in forward movement of RNA polymerase through any block to elongation.

**Termination:** In Eukaryotes, the actual termination of RNA polymerase II activity during transcriptions may take place through termination sites similar to those found in prokaryotes.

However, the nature of individual sites is not known. Such termination sites are believed to be present away. (Sometimes up to one kilo base away from the site of the 3′ end of m RNA)

Transcription by RNA polymerase

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# Chapter-2

# Mitochondria and Release of Energy

**Q.1 Mitochondria Contain**

(a) Outer Membrane (b) Inner Membrane

(c) Inter Membrane (d) Matrix

(e) All of above

**Ans.: (e) All of above**

**Q.2 Mitochondria Contain Enzymes for**

(a) Citric Acid Cycle

(b) Electron Transport and Oxidative Phosphorylation

(c) Fatty Acid Oxidation

(d) All of above (e) None

**Ans.: (d) All of above**

**Q.3 ATP Synthetics or $F_0/F_1$ is present on:**

(a) Mitochondrial Matrix

(b) Inner Mitochondrial Membrane

(c) Outer Mitochondrial Membrane

(d) b & c

**Ans.: (b) Inner Mitochondrial Membrane**

**Q.4 Which of the following is polecat inhibitor of ATP synthesize?**

(a) Kanamycin (b) Streptimycin

(c) a & b (d) Oligomycin

**Ans.: (d) Oligomycin**

**Q.5 Which pair represents isozymes?**

(a) Hexokinase & Fructokinase

(b) Fructokinase & Glucokinase
(c) Glucokinase & hexokinase (d) All
(e) None

**Ans.: (a) All**

**Q.6 Glycolysis is also known as:**

(a) Lori cycle (b) EMP Pathway
(c) Both (d) None

**Ans.: (b) EMP Pathway**

**Q.7 Following are the phases of Glycolysis:**

(a) Preparatory Phase (b) Pay off phase
(c) Both (d) None

**Ans.: (c) Both**

**Q.8 Glycolysis occurs in:**

(a) Cytoplasm (b) Mitochondria
(c) Nucleus (e) None

**Ans.: (a) Cytoplasm**

**Q.9 Kreb Cycle is also known as:**

(a) Citric Acid Cycle (b) Acetyl Co – A catabolism
(c) Both (d) None

**Ans.: (c) Both**

**Q.10 Succinate dehydrogenase enzyme is found in:**

(a) Mitochondrial Matrix
(b) Inner Mitochondrial Membrane
(c) Outer Mitochondrial Membrane (d) None

**Ans.: (b) Inner Mitochondrial Membrane**

**Q.11 How many ATP molecules formed during complete oxidation of one mole of acetyl Co–A:**

(a) 12 (b) 30 (c) 15 (d) None

**Ans.: (a) 12**

**Q.12 Carbon dioxide is produced during:**
(a) glycolysis
(b) the Kreb's cycle
(c) the mitochondrial electron transport chain
(d) substrate level phosphorylation reactions
(e) all of the reactions above produce carbon dioxide
**Ans.: (b) the Kreb's cycle**

**Q.13 The electron transport chain in the mitochondrion pumps protons from the ________ to the ________.**
(a) matrix; intermembrane space
(b) matrix; stroma
(c) intermembrane space; matrix
(d) matrix; cytoplasm
**Ans.: (a) matrix; intermembrane space**

**Q. 14 Given the general equation for respiration, C6 H12*O6 + 6O2 □ 6CO2 + 6 H2O, which of the following is true?**
(a) glucose is reduced to water
(b) oxygen is reduced to carbon dioxide
(c) glucose is oxidized to carbon dioxide
(d) oxygen is oxidized to water
(e) glucose and oxygen are both oxidized to carbon dioxide
**Ans.: (c) glucose is oxidized to carbon dioxide**

**Q.15 The first biochemical pathway to evolve in living things was most likely:**
(a) fermentation
(b) glycolysis
(c) the Kreb's cycle
(d) the mitochondrial electron transport chain
**Ans.: (b) glycolysis**

**Q.16 Which of the following statements about glycolysis is TRUE?**
(a) no ATP are made during glycolysis
(b) Glycolysis requires 32 ATP to work
(c) One redox reaction occurs during glycolysis
(d) Glycolysis occurs only under anaerobic conditions

(e)There are two oxidative phosphorylation reactions during glycolysis
**Ans.: (b) Glycolysis requires 32 ATP to work**

**Q.17 Give an account on EMP Pathway?**

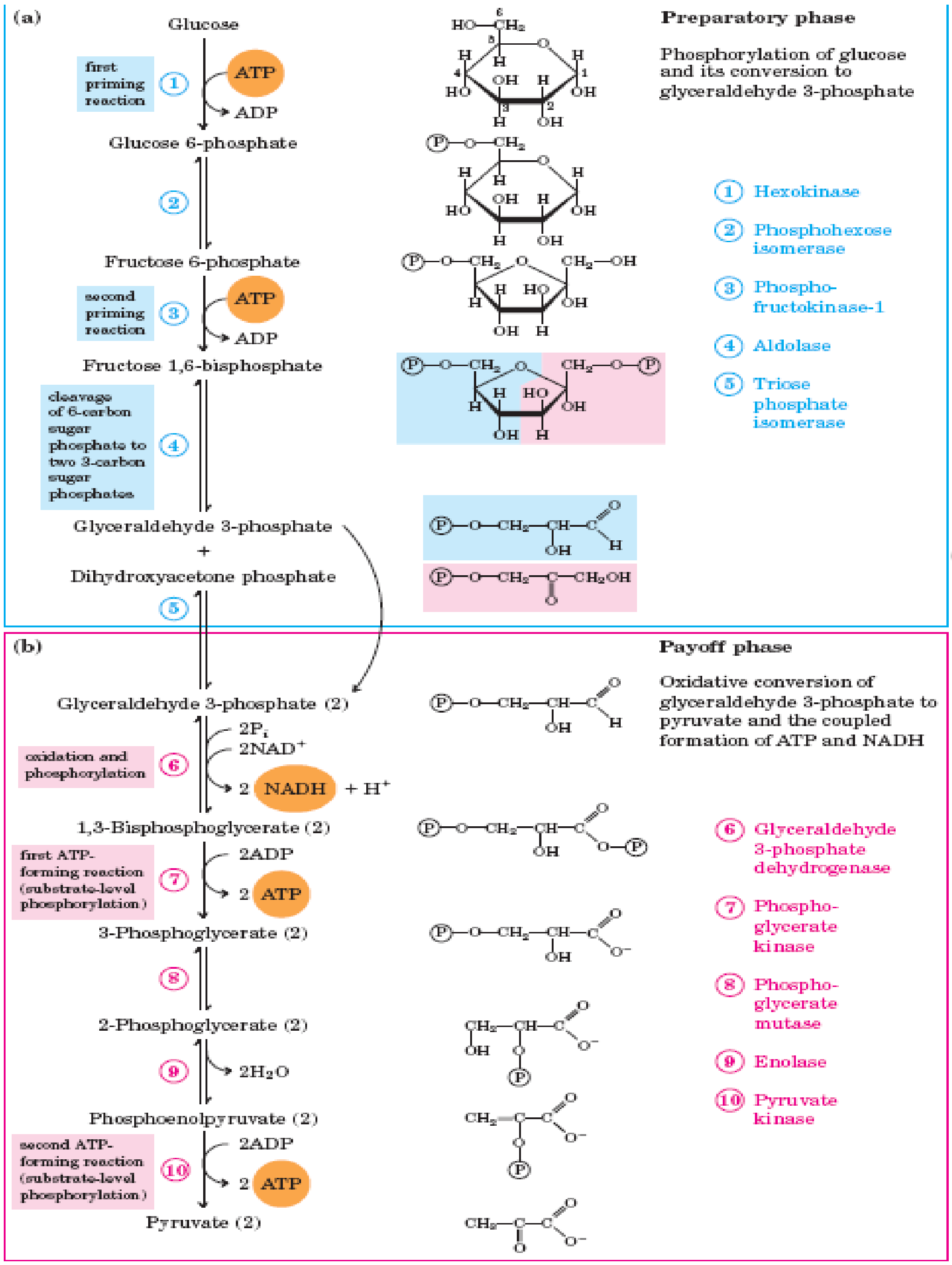
**Ans.:** Glycolysis also called as Embden Mayer Hoff Pathway is an oxidative process in which one mole of glucose is partially oxidized into 2 moles of Pyruvate. This Pathway occurs in cytosol of cell.

**Overall Reaction:** Glucose + $2NAD^+$ + 2ADP + $2H_2PO_4$ → 2Pyruvate + 2NADH + 2ATP + $2H_2O$

Glycolysis consists of two phases:

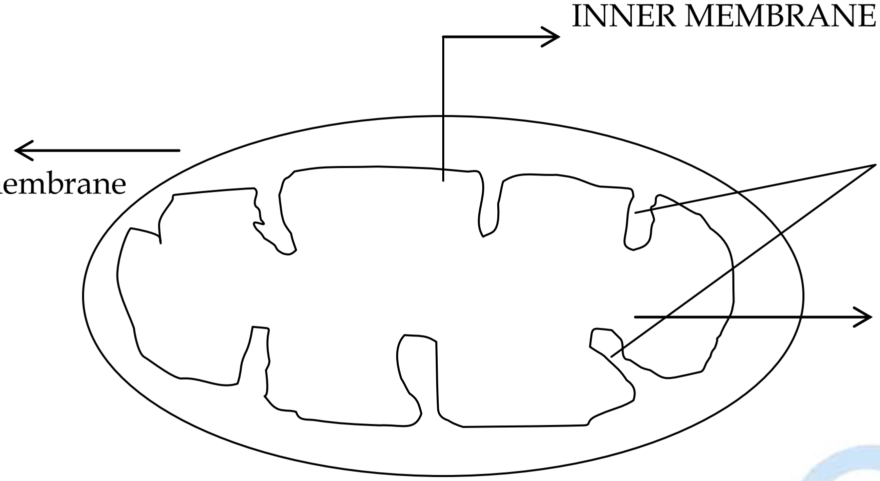
(a) **Preparatory Phase:** Consist of 5 steps. In these reactions Glucose is enzymatically phosphorylated by ATP to yield Fructose 1, 6- diphosphate.

(b) **Pay off Phase:** The last 5 reactions of Glycolysis constitute this phase in which energy liberated during conversion of 3 moles of glyceraldehydes- 3 phosphate to 2 moles of pyruvate by coupled phosphorylation of 4 moles of ADP to ATP. Although 4 moles of ATP are formed in phase II the net overall yield is only 2 moles of ATP per mole of glucose, since 2 moles of ATP are invested in phase I. The Phase II is thus energy conserving.




**Q.18 Give an account of Kreb's cycle and explain role of Mitochondria in it?**

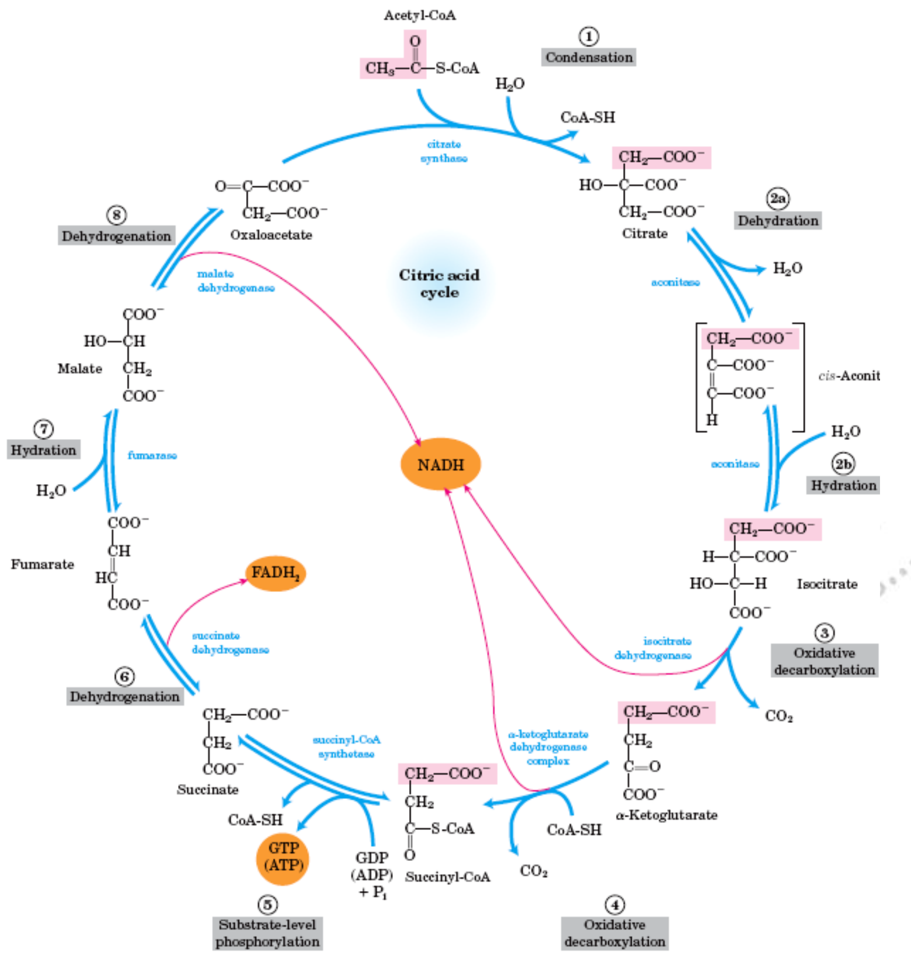
**Ans.:** Mitochondria are double membrane bound mobile as well as plastic organelles. Outer membrane is smooth but inner membrane is highly convoluted; forming folds called cristae and is highly impermeable to small ions due to having very high content of phospholipids cardiolipin. Mitochondrial matrix and inner membrane contain enzymes for Kreb cycle.




Citric acid cycle was discovered by H. A. Kreb & received Nobel Prize in 1953. This cycle occurs in matrix of mitochondria (cytosol in prokaryotes). Citric acid cycle is also known as Tri carboxylic acid cycle. Glycolysis has an aerobic and an anaerobic nature, the citric acid cycle is strictly aerobic in nature. The main purpose of citric acid cycle is the conversion of potential chemical energy into metabolic energy in form of ATP

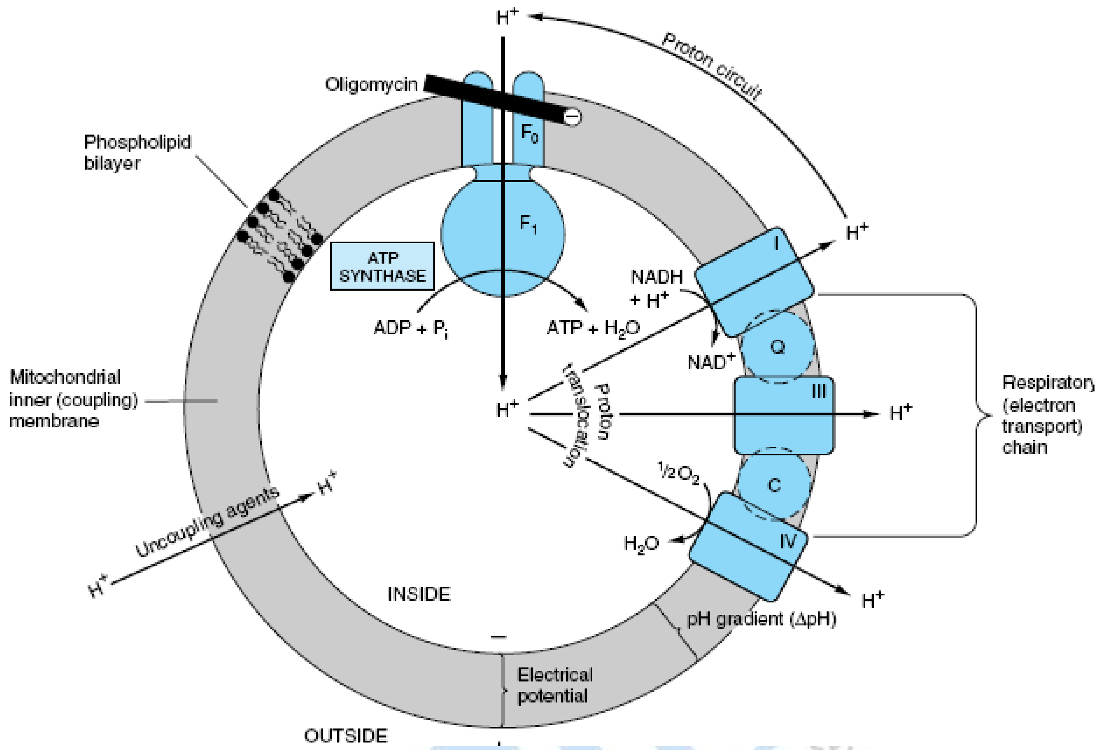
**Energy yield of citric acid cycle:**

| **Reaction** | **Method of ATP Formation** | **ATP yield per mole** |
|---|---|---|
| Isocitrate → α Ketogutarate + $Co_2$ | Respiratory chain oxidation of NADH | 3 |
| α Ketogutarate → Succinate Co A + $Co_2$ | -do- | 3 |
| **Reaction** | **Method of ATP Formation** | **ATP yield per mole** |
| Succinate Co A + ADP + Pi → Succinate ATP | Oxidation at substrate level | 1 |
| Succinate → Fumarate | Respiratory chain oxidation of $FADH_2$ | 2 |
| Malate → Oxaloacetate | Respiratory chain oxidation of NADH | 3 |
| | Total gain of ATP | 12 |




**Q. 19 Give structure and function of ATP Synthetase.**

**Ans.:** Mitochondrial inner membrane contains the ATP – Synthesizing enzyme complex called ATP Synthetase or $F_0$ $F_1$ ATP ase. This enzyme complex has 2 major components $F_0$ & $F_1$. The $F_1$ Component is protruding into matrix from the inner membrane. It is attached by a stalk to $F_0$ component which is embedded in inner membrane and extends across it. $F_1$ contains three $\beta$ subunit that are sites of ATP synthesis. Proton translocation through $F_0$ powers rotation of $\gamma$ subunit of $F_1$ leading to changes in conformation of $F_1\beta$ subunits. By means of this binding change mechanism, the $F_0$ $F_1$ complex harness the proton motive force to power ATP Synthesis.




# Section-D

## Chapter-1

# Chloroplast: Capturing Energy from Sun

**Q.1 Who found that water is an essential requirement for photosynthesis?**

(a) Saussure (b) Priestley

(c) Neil (d) None of the above

**Ans.: (a) Saussure**

**Q.2 Photo system I and II are?**

(a) 900, 680 (b) 700, 680

(c) 680, 900 (e) 680, 700

**Ans.: (b) 700, 680**

**Q.3 Which metal ion is associated with chlorophyll?**

(a) $Mn^{+2}$ (b) Mo

(c) $Fe^{+2}$ (d) $Mg^{+2}$

**Ans.: (d) $Mg^{+2}$**

**Q. 4 The colors of light that are most effective for photosynthesis are**
(a) red, blue, and violet
(b) green, yellow, and orange
(c) infrared and ultraviolet
(d) All colors of light are equally effective
**Ans.: (a) red, blue, and violet**

**Q.5 A photosystem consists of**
(a) a group of chlorophyll molecules, all of which contribute excited electrons to the synthesis of ATP.
(b) a pair of chlorophyll *a* molecules.
(c) a group of chlorophyll molecules held together by proteins.
(d) a group of chlorophyll molecules that funnels light energy toward a single chlorophyll *b* molecule.
**Ans.: (c) a group of chlorophyll molecules held together by proteins.**

**Q. 6 Which photosystem is believed to have evolved first?**
(a) photosystem I
(b) photosystem II
(c) cyclic photophosphorylation
(d) All photosystems evolved at the same time, but in different organisms.
**Ans.: (c) cyclic photophosphorylation**

**Q.7 The final product of the Calvin cycle is**
(a) RuBP
(b) G3P.

(c) glucose.
(d) PGA.
**Ans.: (b) G3P**

**Q.8 The part of the cell that traps sunlight to make sugar is the _____**
(a) Mitochondria
(b) Chloroplast
(c) nucleus
(d) cytoplasm
**Ans.: (b) Chloroplast**

**Q.9 The chloroplast has stacks of _____ called _____.**

(a) thylakoids, grana
(b) grana, thylakoids
(c) ) grana, chlorophyll
(d) ) chlorophyll, grana
**Ans.: (a) thylakoids, grana**

**Q.10 What are the products of photosynthesis?**
(A) water and carbon dioxide
(B) water and oxygen
(C) oxygen and carbohydrate
(D) carbohydrate and water
(E) NAD and glucose

**Ans.: (C) oxygen and carbohydrate**

**Q.11 Define Photosynthesis?**

**Ans.:** Photosynthesis is the process by which organisms convert light energy into chemical energy in the form of reducing power (as NADPH) and ATP and use these chemicals to drive carbon dioxide fixation and reduction to produce sugars.

**Q.12 Write the names of stages of Photosynthesis.**

**Ans.:** (1) Light Reactions: cyclic and non cyclic photophosphorylation
(2) Calvin Cycle

**Q.13 Write the site for Photosynthesis.**

**Ans.:** Chloroplast in mesophyll cells of leaves.

**Q.14 Define Quantum Yield?**

**Ans.:** The number of oxygen molecules produced per photon absorbed is called quantum yield.

**Q.15 Light reactions occur in?**

(a) Stroma (b) Grana

(c) Stroma & Grana (c) None of above

**Ans.: (b) Grana**

**Q.16 Calvin cycle occur in?**

(a) Grana (b) Stroma

(c) Both (d) None of above

**Ans.: (b) Stroma**

**Q.17 Give a brief account on Role of chloroplast Or Function of chloroplast?**

**Ans.:** Chloroplast capture energy form sunlight and use it to fix carbon by process called photosynthesis. Many reactions that occur in chloroplast during photosynthesis are grouped into two categories.

**(a)** In light reactions energy derived from sunlight energized electron in green pigment chlorophyll, electron moves in electron transport chain in thylakoid membrane. Chlorophyll obtain electrons form water, producing $O_2$ as by product. During electron transport process $H^+$ is pumped across thylakoid membrane and resulting electro chemical gradient drives ATP synthesis in stroma. In final step high energy electron are loaded together with $H^+$ on to $NADP^+$, conversion it into NADPH, all these reactions are confine to chloroplast.

**(b)** In carbon fixation reactions ATP and NADPH produced by Electron transfer reactions serve as source of energy & reducing power to drive conversion of $CO_2$ to carbohydrate. Carbon fixation reactions occur in cytosol of chloroplast produce sucrose and other organic molecules in leaves which is exported to other tissues as source of organic molecules and energy.

**Q.18 Describe the structure and organization of chloroplasts?**

**Ans.:** Chloroplast is most prominent members of plastid family of organelles found in all living plant cells. They have permeable outer membrane and less permeable inner membrane. The space between them is called inter membrane space. Inner membrane surrounds large space called stroma. Chloroplast has its own genome and genetic system and stroma therefore contains special set of ribosome, RNA and chloroplast DNA.

A district membrane that form disc like sacs called thylakoids. Thylakoid membrane contains electron transport chains, ATP synthases. Thylakoid membrane is separated form stroma by thylakoid space.

Thylakoids in chloroplast contain pigment require for capturing solar energy called chlorophyll. It gives green color to leaves and absorbs light in violet & blue, red regions in between 400 nm -700 nm.

Chlorophyll is large molecule composed of four 5 member rings called Pyrole rings and central core of magnesium. It also contain side chain called phytol chain, chlorophyll a is major pigment involved in trapping & converting light energy into chemical energy. Chlorophyll molecules act as reaction centers. Carotenoids are also present in thylokoid membrane are called accessory pigments /antenna complexes; harvest light from different wavelengths of spectrum other then of chlorophyll.

The accessory pigments and reaction centre together form Photo system. Photo system I constitutes chl a with maximum absorbtion at 700 nm & Photo system II, chl a with peak absorbtion at 680 nm, act as reaction centre.

**Q.19 What is Light Reaction? Explain.**

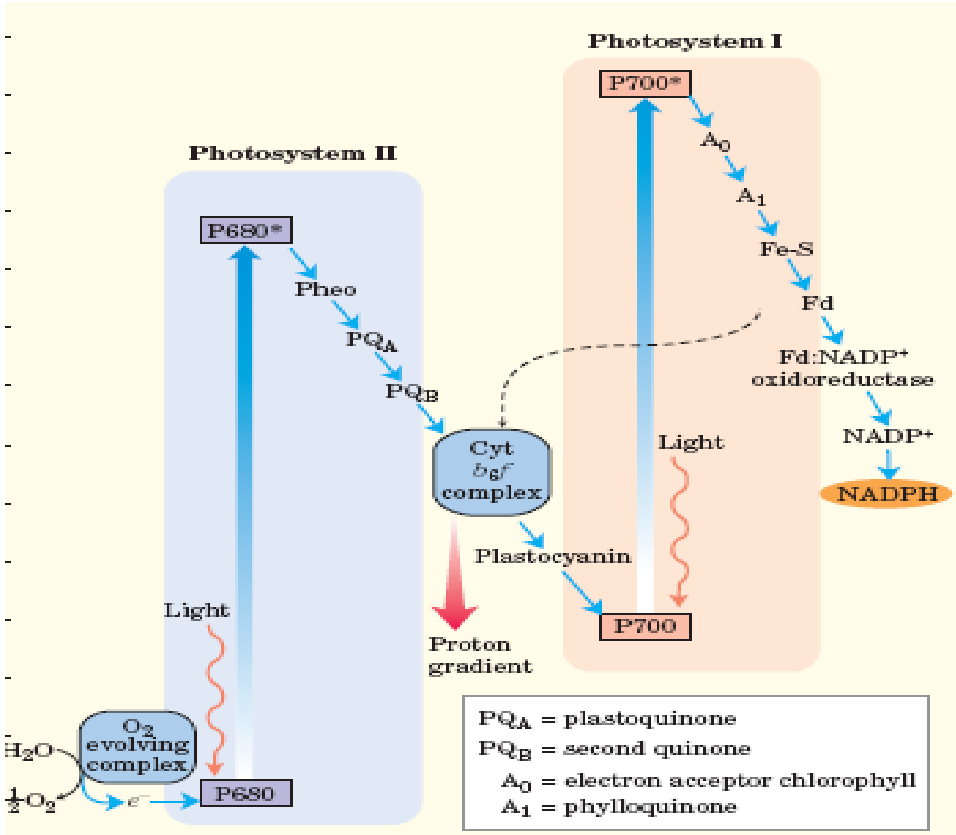
**Ans.:** Light driven reactions of Photosynthesis are called light. It is initiated by absorbtion of light by $P_{680}$ (PS II). $P_{680}$ get excited, transfer electron to acceptor molecule. $P_{680}$ becomes strong oxidizing agent split water to release oxygen. This light dependent splitting of water molecules is called photolysis $Mn^{+2}$, $Ca^{+2}$, Cl are also required for photolysis ,due to break down of water electrons are passed to $P_{680}$ which is able to restore the electrons from water molecules. From $P_{680}$ electron is accepted by primary electron acceptor which gets reduced & donates electron to other downstream components of electron transport chain.

Photo system I is exited on absorbing light and get oxidized. It transfer its electron to primary electron acceptor while transfer electron to Ferrodoxin - NADP reductase to reduce $NADP^+$ to NADPH. NADPH is then used in reduction of $Co_2$ to Carbohydrates in carbon fixation reaction. This reaction requires energy in form of ATP produced from ADP in presence of light called Photophosphorylation.

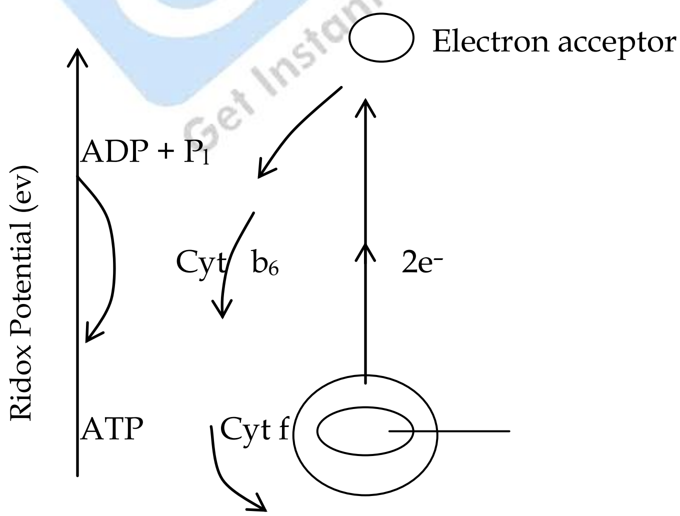
**Q.20 Describe cyclic and non cyclic photo phosphorylation?**

**Ans.:** **(a) Non-cyclic photo phosphorylation:** Is a result of an interaction of Photo system I and PS II. There is Continuous flow of electrons from water to PS II to PS I & finally to NADP, as electron pass downhill, ATP is formed from ADP because the electron flow from water to INADP is unidirectional. This process of ATP formation is called non-cyclic Photo phosphorylation.

**(b) Cyclic photo phosphorylation:** Yield only ATP and produce no net change in oxidation & reduction state of any electron donor or acceptor. The pathway begins when PS I complex absorb solar energy. High energy electrons leave PS I reaction centre chl a molecule but eventually return to it.




**Non cyclic photophosphorylation**



Reaction Centre ($P_{700}$)
Antenrro Molecules

PS I

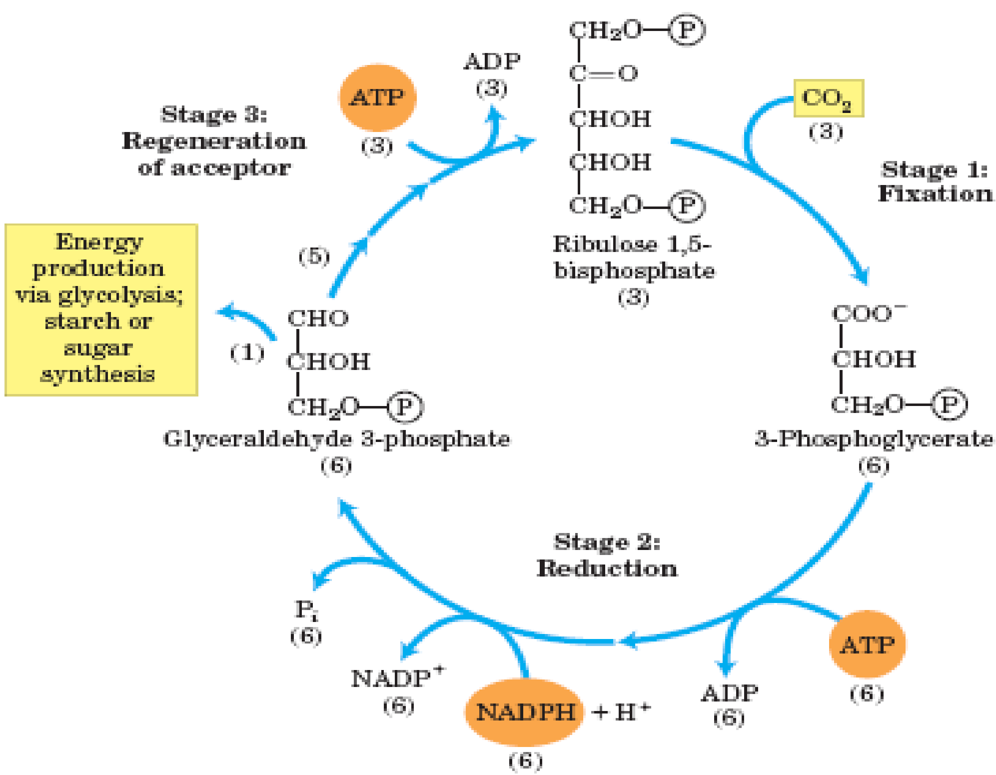
Light **Cyclic – Photo phosphorylation**

**Q.21 Explain Calvin cycle?**

**Ans.:** It is also known as **Biosynthetic** phase or Calvin Benson cycle is a series of biochemical reactions taking place in stroma of chloroplast of Eukaryotic photosynthetic organisms ATP and NADPH formed during Light Reaction are utilized for assimilation of $Co_2$ to Carbohydrates. It is also known as $C_3$ pathway because the first stable compound forms is 3 – Carbon molecules called 3 – phosphoglycerate. Plant which fix $Co_2$ using $C_3$ path way called $C_3$ plants.

The reaction of this cycle is loaded into 3 phases.

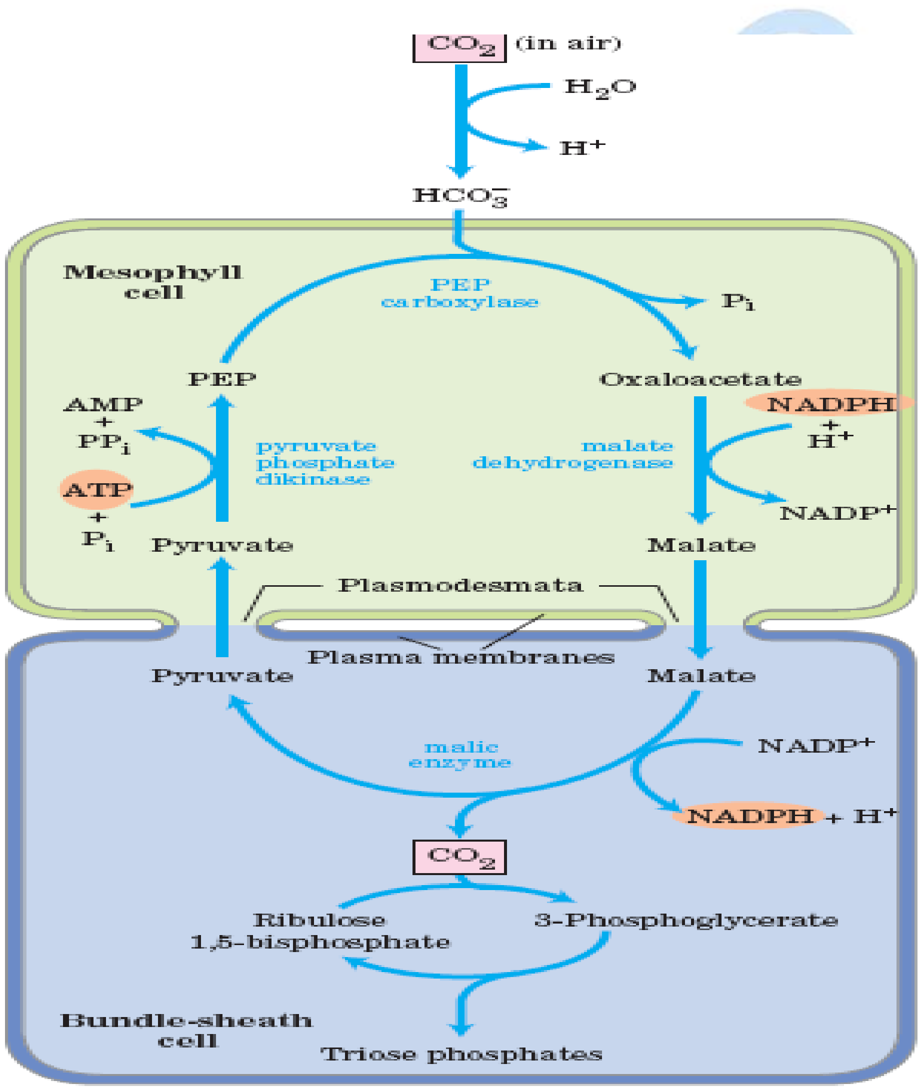
(1) Carbon Fixations (2) Reductions (3) Regenerations



## CALVIN – CYCLE

**Q.22 Explain $C_4$ pathway? Give examples of C4 plants.**

**Ans.:** It is $CO_2$ concentrating mechanism Phosphoenol pyruvate (PEP) is carboxylated to $C_4$ acids which are first product of photosynthesis. $C_4$ acids are formed in mesophyll and diffused to bundle sheath where they are decarboxylated. Buddle sheath contain Rubisco of Calvin cycle results in formation of $C_3$ compound which returns to mesophyll. Examples of C4 plants are maize, sugar cane etc.




$C_4$ plants possess two types of photosynthetic cell layer surrounding vascular bundle called bundle sheaths which are thick walled & suberized and are not directly connected to inter cellular spaces of mesophyll. Mesophyll cells are connected to bundle sheath by large numbers of plasmodesmata.

**Q.23 what do you mean by CAM pathway? Explain.**

**Ans.:** Crassulacean acid Metabolism (CAM) refer to a mechanism of photosynthesis that is different form $C_3$ & $C_4$ pathway. Occurs only in succulents and plants that grow in dry conditions e. g.; Cactus, pineapple etc. In CAM plants, $CO_2$ is taken up by leaves on green stems through stomata which remain open in night, during day stomata remain closed in these plants to conserve moisture. $CO_2$ taken up in night is fixed to form malic acid which is stored in vacuole. Malice acid formed during night is used during day as a source of $CO_2$ for photosynthesis to proceed through $C_3$ pathway.

This pathway is a kind of an adaptation which allows carrying out photosynthesis without loss of water.

□ □ □

# Chapter-2

# Enzymes

**Q.1 who coined the term Enzyme?**

(a) Louise Pasteur (b) Sumner

(c) Kuhne (d) None of the above

**Ans.: (c) Kuhne**

**Q.2 Who is known as Father of Modern Enzymologist?**

(a) Buchner (b) Khune

(c) Northrop and Kunity (d) Sumner

**Ans.: (d) Sumner**

**Q.3 Write names of two model gain to explain formation of Enzyme-Substrate Complex?**

**Ans.:** (a) Fischer's Lock and key Model.

(b) Koshland's Induced Fit Model.

**Q.4 Match the Following:**

| **Vitamin** | **Coenzyme/Cofactors** |
|---|---|
| (a) Thiamine | (1) Pyruvate Kinase |
| (b) $Fe^{+2}$ or $Fe^{+3}$ | (2) Coenzyme A |
| (c) Riboflavin | (3) Carbonic anhydrase |
| (d) $K^{+}$ | (4) FAD and FMN |
| (e) Pantothenic Acid | (5) cytochrome Oxidase, Catalase |
| (f) $Zn^{+2}$ | (6) Thiamine Pyrophosphate |

**(I)** (a) – (6), (b) – (5), (c) – (4), (d) – (1), (e) – (2), (f) – (3)

**(II)** (a) – (6), (b) – (4), (c) – (1), (d) – (5), (e) – (3), (f) – (2)

**(III)** (a) – (6), (b) – (2), (c) – (3), (d) – (1), (e) – (5), (f) – (4)

**(IV)** None of these

**Ans.: (I)** (a) – (6), (b) – (5), (c) – (4), (d) – (1), (e) – (2), (f) – (3)

**Q.5 Which of the following is true for specific constants.**

(a) Kcat x Km, affinity (b) $\frac{\text{Km}}{\text{Kcat}}$, enzyme concentration

(c) $\frac{\text{Kcat}}{\text{Km}}$ Measure enzyme efficiency (d) none of the above

**Ans.: (c)** $\frac{\text{Kcat}}{\text{Km}}$ **measure enzyme efficiency**

**Q.6 Which of the following does NOT apply to an enzyme.**

(a) Catalyst
(b) Inorganic
(c) Protein
(d) All of the above apply to an enzyme

**Ans.: (b) Inorganic**

**Q.7 The non protein part of an enzyme is known as**

(a) Holoenzyme
(b) Apoenzyme
(c) Prosthetic group
(d) Vitamins

**Ans.: (c) Prosthetic group**

**Q.8 The polypeptide or protein part of the enzyme called**

(a) Holoenzyme
(b) Apoenzyme
(c) Prosthetic group
(d) Zymogen

**Ans.: (b) Apoenzyme**

**Q.9 Turn over number of an enzyme is dependent upon**

(a) Size of enzyme
(b) Molecular weight of enzyme
(c) Active sites
(d) Concentration of substrate

**Ans.: (c) Active sites**

**Q.10 Coenzymes combine with**
(A) Proenzymes
(B) Apoenzymes
(C) Holoenzymes
(D) Antienzymes

**Ans.: (B) Apoenzymes**

**Q.11 Write the chemical nature of Enzymes?**

**Ans.:** Proteinaceous

**Q.12 Define Enzymes?**

**Ans.:** Enzymes are catalyst (Biocatalyst) that changes the rate of reaction without being changed themselves. Enzymes are highly specific and their activity can be regulated.

**Q.13 Differentiate between Endo & Exo enzymes?**

**Ans.:** Enzymes that usually act within the cells in which they are produced are called Endo enzymes whereas, certain enzymes which are liberated by living cells, catalyze useful reactions outside cell in its environment are called Exo enzymes**.**

**Q.14 What are Simple and Conjugated Enzymes?**

**Or**

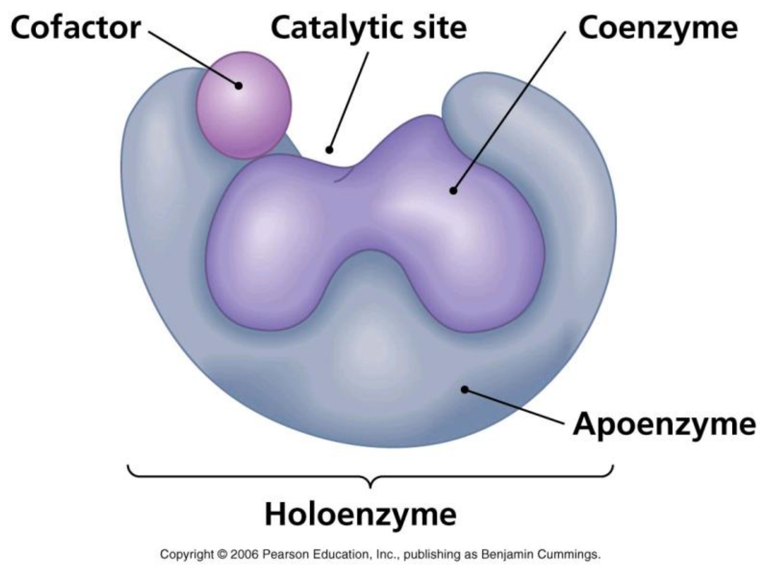
**Give a brief account of Coenzymes/Cofactors.**

**Ans.:** **Simple Protein Enzymes:** are completely protein e.g. amylase, papain etc. **Complex Protein Enzymes:** are composed of a protein portion called the apoenzyme and one or more nonprotein portions. There are two main categories of such substances:

**Cofactors** are inorganic metal ions such as iron, magnesium or zinc.

**Coenzymes** are organic compounds composed of vitamins or vitamin derivatives. Examples include $NAD^+$, $NADP^+$ and $FAD^+$, all of which serve in the transfer of electrons and hydrogens released by catabolic pathways.

Both cofactors and coenzymes help to complete the structure of a conjugated enzyme, forming a **holoenzyme.**




**Q.15 What are General characteristics of Enzymes.**

**Ans.:** (1) Enzymes are Colloidal in nature.

(2) Enzymes exhibit enormous catalytic Power.

(3) They are specific in action.

(4) Enzymes are heat sensitive.

(5) They are capable of bringing about reversion in chemical reaction.

(6) pH value also controls the activity to great extent.

**Q.16 Define the following?**

**(a) Active Site (b) Transition State (c) Activation Energy**.

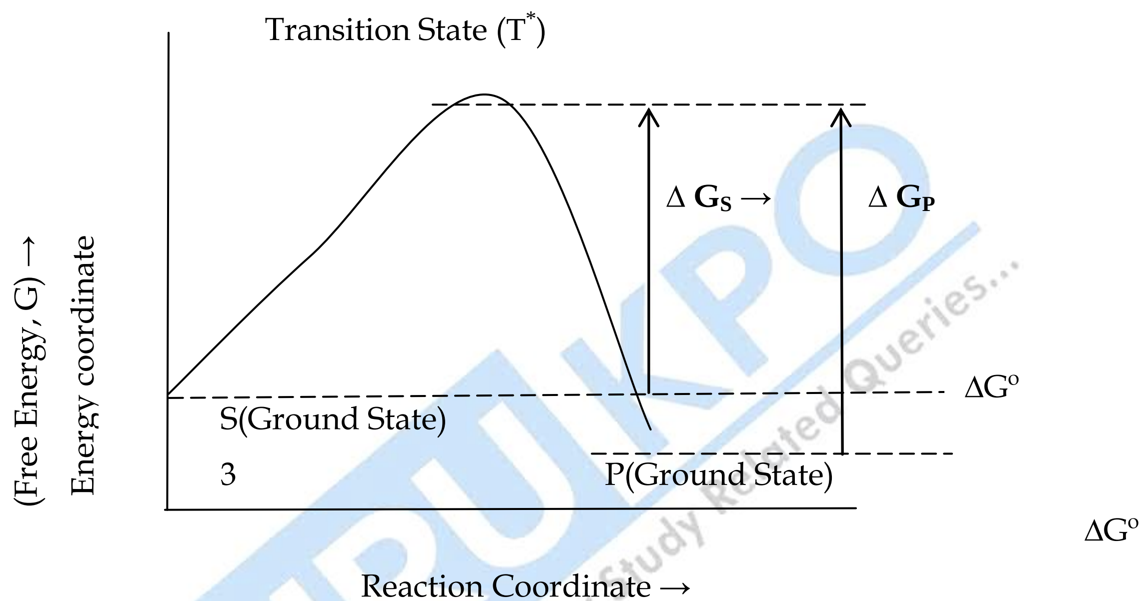
**Ans.:** **(a) Active site:** active site of an enzyme is the region often a cleft or crevice on surface of enzyme that binds the substrate and converts it into product. It is usually a small part of whole enzyme and is a three dimensional entity formed by amino acid residues.

**(b) Transition State :** At top of energy hill is a point at which decay to S or P state is equally probable is called transition state and is different from reaction inter mediate.

(c) **Activation Energy:** The difference between the energy levels of ground state and transition state is called Gibbs free energy of activation or simple activation energy.

**Q.17 Give the free energy diagram for chemical reaction, S** $\rightarrow$ P

**Ans.:**




Where

S = Free energy of Substrate

P = Free energy of Product

$\neq$ = Activation energies for the two reactions; S → P & P → S

$\Delta G^o$ = Overall standard free energy change in moving Trans to P

**Q.18 What is Turn over Number?**

**Ans.:** The number of substrate molecules converted into product per unit time when enzyme is fully saturated with substrate is called Turn over Number.

**Q.19 What are Isoenzymes?**

**Ans.:** Many enzymes occur in more than one molecular form in same tissue or ever in same cell in such cases the different forms of enzymes catalyze some reaction but they possess different kinetic properties and different amino acid composition, These multiple forms of enzymes are called Isoenzymes or Isozymes.

Examples; Lactic dehydrogenase (LDH) which exists in 5 possible forms in various organs of most vertebrates.

Reaction; Lactic + $NAD^+ \xrightarrow{LDH}$ Pyruvate + NADH + $H^+$

Following are the different types of LDH found;

(a) **Heart LDH:** 4 identical subunits called H subunits active at low level of Pyruvate.

(b) **Muscle LDH:** 4 identical subunits called M subunits and is active at high concentrations of Pyruvate.

Combination of H and M subunits produce 3 additional types of hybrid enzymes & 5 possible forms e. g. $H_4$, $H_3M$, $H_2M_2$, $HM_3$, $M_4$ server concentration of LDH is often used in diagnosis of myocardial infarction.

Other noteworthy, examples of Isoenzymes are MDH (malic dehydrogenase) hexokinase etc.

**Q.20 Give a brief account on Nomenclature of enzymes.**

**Ans.:** Nomenclature of enzymes is based on the following points:

**(a)** **Substrate acted upon by enzyme:** enzymes have been named by adding suffix ase in the name of substrate catalyzed e. g. Lipases, Sucrose.

**(b)** **Type of reaction catalyzed:** e.g. hydrolyses (Catalyses hydrolysis), oxidizes (oxidation) etc.

**(c)** **Substrate acted upon & type of reaction catalyzed:** e.g. Succinate dehydrogenase catalyze dehydrogenation of substrate succinic acid.

**(d)** **Substance that is synthesized:** e. g. Fumarase that forms fumarate irreversibly form L malate.

**(e)** **Chemical Composition of enzymes :**

(1) Pepsin → Consisting protein only.

(2) Carbonic anhydrase → containing protein and anhydrase cation.

(3) Pyruvate oxidase → Containing protein and organic compound (Flavo proteins)

**(f)** **Substance hydrolyzed and group involved :**

(1) Carbohydrate hydrolyzing enzymes; Glycosidases → cellulose.

(2) Protein hydrolyzing enzymes : Endo peptidases → Pepsin, trypsin
Endopeptidases → dipeptidases, tripeptidases.

(3) Lipid hydrolyzing → lipases, esterases.

**Q.21 What is Michaelis Menten hypothesis. Derive Michaelis Menten equation?**

**Ans.:** Michaelis and Menten while studying hydrolysis of sucrose catalyzed by enzyme invertase proposed Michaelis Menten hypothesis on the basis of following assumptions.

(1) Only single substrate and a single product are involved.

(2) Process provides essentially to completion.

(3) Concentrating of substrate is much greater than that of enzyme in system.

(4) An intermediate enzyme substrate complex is formed.

They postulates that the enzyme (E) forms a weakly bonded complex (ES) with substrate (S) (ES) on hydrolysis yield product and free enzyme (E).

**Reaction :** $E + S \rightleftharpoons ES \rightarrow E + P$

Following; symbol may be used for deriving Michelis Menten equation:

$(E_t)$ = Total Concentration of enzyme.

$(S)$ = Total Concentration of substrate

$(ES)$ = Concentration of Enzyme Substrate complex.

$(E_t) - (ES)$ = Concentration of free enzyme.

Now,

Rate of appearance of products (is velocity: V) is proportional to concentration of the enzyme substrate complex

$$V = K\,(ES) \qquad \text{\_ \_ \_ \_ (1)}$$

Maximum reaction rate $V_m$ will occur at a point when total enzyme $E_t$ is bound to substrate. Then maximum concentration of ES will be equal to total enzyme concentration $E_t$

$$V_m = K\,(E_t) \qquad \text{\_ \_ \_ \_ (2)}$$

Dividing eq $^n$ (1) by (2)

$$\frac{V}{Vm} = \frac{(ES)}{(E_t)} \qquad \text{\_ \_ \_ \_ (3)}$$

For, reversible reaction, E + S  E S equilibrium constant for dissociation of ES as km is equal tv

$$Km = \frac{(E_t) - (ES) \times (S)}{(ES)} \quad ----(4)$$

$$(ES) \times Km = (E_t) \times (S) - (ES) \times (S)$$

Or $$(ES) \times Km + (ES) \times (S) = (E_t) \times (S)$$

Or $$\frac{(ES)}{(E_t)} = \frac{(S)}{Km + (S)} \quad ----(5)$$

Substituting the value of $\frac{((ES)}{(E_t)}$ form eq. (3) to eq. (5) ;

$$\frac{V}{Vm} = \frac{(S)}{Km + (S)} \quad ----(6)$$

Or

$$V = \frac{Vm \times (S)}{Km + (S)} \quad ----(7)$$

Or $$Km = (S)\left[\frac{Vm \;\; -1}{V}\right] \quad ----(8)$$

equations (7) is called **Michaelis Menten equation** and the equilibrium constant Km is called **Michaelis constant** is a measure of affinity of an enzyme for its substrate.

**Q.22 Write short note on classification of enzymes.**

**Ans.:** The International Union of Biochemistry (IUB) instituted a Systemic Scheme for enzyme. Each enzyme is now classified and named according to type of chemical reaction it catalyzes:

**(1)** **Oxidoreductases:** Catalyze oxidation – reduction reactions e.g.; dehydrogenase, oxidase reductases etc.

**(2)** **Transferases:** Catalyze reaction that involves transfer of groups from one molecule to another e. g.; amino, carboxyl etc.

**(3)** **Hydrolyses:** Catalyze reactions in which change bonds is accomplished by adding water e.g.; esterase, peptidases.

**(4)** **Lyses :** Catalyze reactions in which group $H_2O$, $CO_2$, $NH_3$ are remove to form double bond or are added to double bond e.g.; Decarboxylases, Synthases.

**(5)** **Isomerases:** Catalyze intra molecular rearrangements and yield isomeric forms. The epimerases Catalyze inversion of asymmetric carbon atom, mutases Catalyze intra molecular transfer of functional group.

**(6)** **Ligases:** Formation of C – C, C – S, C – O & C – N bonds and energy of these reactions is supplied by ATP hydrolysis e.g.; Synthetase, Carboxylases.

**Q.23 Give an account of Allosteric regulation of enzymes?**

**Or**

**What is feed back inhibition? What are allosteric enzymes?**

**Ans.:** In biological systems the rates of many enzymes are altered by presence of other molecules such as activators and inhibitors collectively called as effectors.

A, common regulation of metabolic pathway is when an enzyme early in the pathway is inhibited by end-product of metabolic pathway in which it is involved called **feed back inhibition.** End product of metabolic pathway involving multiple enzyme reactions, it will bind to enzyme at control point at a site other than active sites: Such enzymes are called **Allosteric enzymes.**

Allosteric enzymes give **Sigmoid Curve** rather then hyperbolic plots predicted by Michaelis Menten equation.

Allosteric enzymes are made up of two or more sub units. Enzymes for which substrate and effector are same called **homotropic** and enzymes for which effectors and substrate are different called **heterotropic.**

Example of Allosteric enzyme: **Aspartate transcarbamoylase used in Pyrimidine biosynthesis.**

□ □ □

# Chapter-3

# Vitamins

**Q.1 Milk is deficient in which vitamins?**
(A)Vitamin C
(B) Vitamin A
(C) Vitamin B2
(D) Vitamin K

Ans.: (A) Vitamin C

**Q.2 Vitamin $B_{12}$:**

(A) is fat-soluble

(B) requires a glycoprotein from absorption

(C) contains a haeme ring

(D) is water soluble

**Ans.:** Both b and c

**Q. 3 Which one of these vitamins has a role as an antioxidant?**
(A) Biotin
(B) Folate
(C) Niacin
(D) Pantothenic acid
(E) Vitamin E
**Ans.:** (E) Vitamin E

**Q.4 Deficiency of which one of these vitamins is a major cause of blindness?**
(A) Vitamin A
(B) Vitamin B12
(C) Vitamin B6
(D) Vitamin D
(E) Vitamin K
**Ans.:** (A) Vitamin A

**Q.5 Which of the following vitamins is essential for fatty acid synthesis?**
(A) Folate
(B) Pantothenic acid
(C) Vitamin B6
(D) Vitamin B12
(E) Vitamin C
**Ans.:** (B) Pantothenic acid

**Q.6 Which one of these vitamins is involved in blood clotting?**
(A) Vitamin B6
(B) Vitamin B12
(C) Vitamin D
(D) Vitamin E
(E) Vitamin K
**Ans.:** (E) Vitamin K

**Q.7 Which of the following vitamins provides the cofactor for pyruvate dehydrogenase?**
(A) Folate
(B) Niacin
(C) Riboflavin
(D) Thiamin
(E) Vitamin B6
**Ans.:** (D) Thiamin

**Q.8** Which one of these vitamins has a role in oxidation and reduction reactions?
(A)Folate
(B)Niacin
(C)Pantothenic acid
(D)Vitamin A
(E)Vitamin B6
**Ans.** (B)Niacin

**Q.9 Which one of these vitamins is required for DNA synthesis?**
(A) Biotin
(B) Folate
(C) Pantothenic acid
(D) Vitamin B6
(E) Vitamin B12
**Ans.:** (B) Folate

**Q.10 Deficiency of which one of these vitamins may lead to haemolytic anaemia?**
(A) Vitamin B6
(B) Vitamin B12

(C) Vitamin D
(D) Vitamin E
(E) Vitamin K
**Ans.:** (D) Vitamin E

**Q.1 Who introduced the term VITAMINE?**

**Ans.:** Funk with Dr. Max Nierenstein.

**Q.2 Who gives alphabetical nomenclature of vitamins?**

**Ans.:** Sir J. C. Drummond.

**Q.3 Define vitamins.**

**Ans.:** According to Franz Holfmeister vitamins are substances which are indispensable for growth and maintenance of animal organism, which occur both in animals and plants and are present in small amounts in food.

**Or**

Vitamins refer to substances distinct form major compounds of food, required in minute quantities and their absence causes specific deficiency.

**Q.4 Give a brief idea about general characteristics of vitamins.**

**Ans.:**
**(1)** Widespread occurrence in nature both in plant and animal worlds.
**(2)** All common food stuffs contain more than one vitamin.
**(3)** The plants can synthesize all vitamins where as only a few vitamins are synthesized in animals.
**(4)** Human body can synthesize same vitamins e.g.; Vit. A, B, C, D.
**(5)** Most vitamins have been artificially synthesized.
**(6)** All the cells of body store vitamins to some extent.
**(7)** Vitamins are partly destroyed and are partly excreted.
**(8)** Vitamins are non-antigenic.
**(9)** Vitamins carry out functions in very low concentrations and their daily requirement is very low.
**(10)** Vitamins are effective when taken orally.
**(11)** Need of vitamins increases with the increasing age.

**(12)** Synthetically made vitamins are just as nutritionally good as natural vitamins.

**Q.5 How Vitamins are classified and comment on the storage of vitamins in Body?**

**Ans.:** Two categories of vitamins are usually recognized.

**(a)** Fat soluble vitamins.

**(b)** Water soluble vitamins.

**Fat soluble Vitamins:**

(1) Not really soluble in water.

(2) Contain C, H, O e.g. are Vitamins A, D, E, K.

(3) Are isoprenoid compouds.

(4) Fat soluble vitamins are stored in liver.

(5) Are building blocks of many naturally occurring oily, greasy or rubbery substances of plant origin

(6) Although Fat soluble vitamins are storable but increase in their uptake can result in toxic conditions (also called as hyper vitaminoses)

**(b) Water soluble Vitamins**

(1) Besides C, H, O contain (N).

(2) Are catalytic factors and they having very vital role to play in biochemical reactions characteristic of all living objects.

(3) B, C: [choline, inositol, p-amino benzoic acid befavanoeds, α-lipoic acid are also frequently included in this category. But some do not considered them as true vitamins.

(4) Stored in lesser amounts in cell vit. C is stored in adrenal cortex.

**Q. 6 Give a brief account of Fat soluble Vitamins covering following points- property and their Role.**

**Ans.:** Vitamins A, D, E, K is Fat soluble vitamins.

**(I) VITAMIN A**

- First isolated form fish liver at by Holmes.
- Liver oils of various fishes are richest natural sources of vitamin A.

- It is supplied by all pigmented (yellow) vegetables and fruits such as carrots, pumpkins, yellow corn, tomatoes etc.
- Absent in vegetable fats and oils.

**Structure:** Found in two forms $A_1$ and $A_2$

Corticoids ⟶ Vitamins A
(Pro-vitamin A)

- $\alpha, \beta, \Upsilon$ Carotenes come under carotenoids.
- Vitamin $A_1$ is primary alcohol called retinol ($C_2$ $OH_{29}$ OH) contain $\beta$ -ionone ring.
- Vitamin $A_2$ contain additional conjugate double bond between carbon atoms 3 & 4 of $\beta$ ionone rings, also called as 3-dehydorretinol

**Properties:** oxidizing agents.

- Relatively less stable in air unless protected by vitamin E.

**Role and Metabolism:** $\beta$ Carotene (From Plants)
↓
Retinal
↓
Retinoic acid ← Retinol
↓
Retinylester → Absorbed through lymphatic system & stored in Liver

- Liver can also convert retinol to retinoic acid which is also, quickly absorbed from the intestine.
- Vitamin A maintains Skin's epithelial cells and lining of digestive, respiratory and genitourinary system.
- Guards against cancer by producing cell wall from undesirable oxidation & scavenging the products of oxidation.

**Deficiency disease**:

(1) Xeropthalmia (blindness in childhood)

(2) Keratomalacia (corneal disease)

(3) Phrynoderma : Skin lesion

## (II) VITAMIN D

- Two forms Vitamin $D_2$ and $D_3$ are more important.
- Vitamin D is present in its pro vitamin form in human skin and is easily converted to active form by irradiation with ultraviolet light.
- Best source are Liver oils of fishes, egg yolks.
- Absent in vegetable fats and oils.

**Structure:**

(1) Ergosterol→ Inter Mediates → Ergocalciferol or Viosterol (Vitamin $D_2$)

(2) 7-dehydrocholestrol → Cholecalciferol (Vitamin $D_3$)

**Biologically active form of Vitamin $D_3$ is:** 25 – hydro cholesterol more polar and has an additional OH group at C 25. It is synthesized in liver and is converted to 1, 25 – dihydroxy cholecalciferol in kidneys.

**Properties:** (1) Soluble in fat and fat solvents.

(2) White and crystalline substance.

(3) Resistant to oxidation and not affected by acids and alkalis.

**Role and Metabolism:**

- Vitamin D has important role in calcification of bones and teeth by inverse absorbtion of $Ca^{+2}$ and phosphate salts.
- Pro vitamins D3 can be synthesized within human body that and therefore not required in diet.
- Increased need of this vitamin is required in growth and during pregnancy.

**Deficiency Diseases:**

**Rickets:** No Calcification of bones.

**Osteomalacia:** Softening of bones, C/P ratio gets disturbed.

## (III) VITAMIN E

- Also called as anti fertility factor.
- Were isolated from wheat germ oil by Evans (found in tow form → $\alpha$ and $\beta$ tocopherol) in wheat germ oil.

- Plant oils such as wheat germ, rice, corn, soybean & meat, milk, egg etc are also source of Vitamin E.
- Widely spread forms of vitamin E are α, $\beta$, ϒ tocopherols.

**Structure:** The other name for Vitamin E is Tochopherols which is a lipid molecule.

- A various tocopherols differ form each other in substitutes on carbon 5, 7 and 8.

Compositon of variable segment of different Tocopherols.

| Types of Tocopherol | Substituents of carbon atoms | | |
|---|---|---|---|
| | 5 | 7 | 8 |
| **Alfa** $\alpha$ | **$CH_3$** | **$CH_3$** | **$CH_3$** |
| **Beta** $\beta$ | **$CH_3$** | **H** | **$CH_3$** |
| **Gamma** ϒ | **H** | **$CH_3$** | **$CH_3$** |

**Properties:**

(1) Vitamin E is resistant to heat and acids.

2) Are antioxidants.

(3) Vitamin E can be destroyed by UV rays.

(4) It is found in the non specifiable fraction of the vegetable oils.

**Role and Metabolism:**

(1) Duet to its antioxidizing property, it is commercially added to food to retard their spoilage.

(2) Tocopherols protect mitochondrial system from inactivation by fat peroxides.

(3) Catabolism of $\alpha$ - tocopherol involves both the oxidative cleavage of chromon ring to yield quinine or hydroquinone like compounds and degradation of isprenoids side chain.

**Deficiency Disease:**

(1) Development of sterility in rats.

(2) Muscular Dystrophy in herbivores like rabbits and guniea pigs.

**(III) VITAMIN K**

(1) Also called as antihemorragic factor or Coagulation vitamin.

(2) Two naturally occurring forms of vitamin K are vitamin $K_1$ and vitamin $K_2$.

(3) Vitamin $K_1$ occurs in green vegetables like spinach, alfalfa, cabbage and Vitamin $K_2$ found in intestinal bacteria and putrefied fish meal.

**Structure:**

(1) Vitamin $K_1$ and $K_2$ are the derivatives of quinones.

(2) These two forms differ in the composition of the side chain present at carbon 3 of napthoquinone ring.

(3) Vitamin $K_1$ ($C_{31}H_{46}O_2$) has side chain of phytol radical whereas vitamin $K_2$ ($C_{41}H_{56}O_2$) has Difarnesyl radical as a side chain.

(4) Common analogues of napthoquinones possessing vitamin K activity are menadione ($K_3$) and phthiocol.

**Properties:**

(1) Vitamin $K_1$ is yellow visual oil & Vitamin $K_2$ is yellowish crystalline solid.

(2) It can be destroyed by irradiations strong acids, alkalis & oxidizing agents.

(3) It is light sensitive and therefore kept in dark bottles.

**Role and Metabolism:**

(1) It is fat soluble and absorbed in presence of bile.

(2) Vitamin K has essential role in prothrombin biosynthesis needed in process of blood clotting & produced in liver.

(3) It is also required in Electron transport system and oxidative Phosphorylation in Mitochondria.

**Deficiency Disease:**

(1) Hemorrhage due to loss of blood clotting.

(2) Steatorrhea → Diminished intestinal absorbtion of lipids.

**Coenzyme Q**

(1) Components of Mitochondrial lipids.

(2) Coenzyme Q serves as electron transport of agent

(3) Contain 6 to 10 isoprene unit.

**Stigma sterol**

(1) Fat soluble vitamin.

(2) It is plant sterol isolated from soybean and wheat germ oils.

(3) Also called as anti stiffness factor.

**Q.7 Write short note on Vitamin B Complex.**

**Ans.:** At present Vitamin B Complex is known to consist of group of at least 13 components usually named as $B_1$, $B_2$, and B3 etc.

**Vitamin $B_1$:** Also called as Thiamine and commonly known as anti beriberi factor found in all plant and animal food. Thiamine is 2, 5 diethyl – 6 amino pyrimidine bonded to 4 methyl – hydroxyethyl – thiozole through methylene linkage. Thiamine is while crystalline Substance, readily soluble in water destroyed at elevated temperature but it is stable in acidic medium.

It is present mainly as its coenzyme (TPP) which participates in decarboxylation of $\alpha$ - Keto acids and in Trans ketolation. It deficiency causes Berry Berry:

**Vitamin $B_2$:** Also known as Riboflavin or Lactoflavin or yellow enzyme. Found in Milk, cheese, eggs Riboflavin (CH $H_2O$ $N_4$ $O_6$) belongs to water soluble pigments called lyochromes. Thiamine molecule consists of sugar alcohol D ribitol attached to iso alloxazinc ring. Riboflavin is bright orange yellow crystalline powder stable to heat and acid but decomposed by alkalis & light. Riboflavin is phosphorlated and converted to FMN (flavin mono nucleotide) which is essential in biosynthesis of fats. They play key role in cell metabolism & function in accepting hydrogen atom form reduced pyridine nucleotides person deficient in vitamin $B_2$ show chelosis (fissuring at corners of mouth), Glossitis, smooth tongue and loss of papillary structure occurs.

**Vitamin $B_3$ (Pantothenic acid):** Also known as filtrate or yeast factor. The coenzyme form of this vitamin is Coenzyme A or CoA- SH found in Vegetables like potatoes, cabbage, fruits like peanuts etc. Pantothenic acid is an amide of pantoic acid and $\beta$ - alanine. It is pale yellow viscous oil stable in oxidizing, reducing agent and destroyed by acidic and alkaline medium Vitamin $B_3$ participate information of biologically important Co – A and function as Thioester of Carboxylic acids. Deficiency of vitamin $B_3$ causes de pigmentation of skin, hairs, atrophy of adrenal cortex in animals like rat.

**Vitamin $B_5$:** Also known as pellagra preventive factor (PP) factor. Chemically it is called Nicotinic acid, most abundantly found in yeast, Liver, Pork, red meat are good sources of vitamin $B_5$.

Niacin or vitamin $B_5$ is pyridine derivative and its amide is known as Nicotinamide. The conversion of niacin to niacin amide takes place in kidney. The niacin in Man is derived from amino acid tryptophan. The two forms (Coenzyme forms) of vitamin NAD and NADP carry out Reduction of flavin coenzymes and oxidation of alcohols, aldehydes, amino acids. Deficiency of niacin causes pellagra in man and black tongue in dogs.

**Vitamin $B_6$:** This group includes three compounds Pyridoxine, Pyridoxal, Pyridoxamine. Also called as anti dermatitis factor, cereals, peas, sweet potatoes, egg yolk, fish, beaf and cow's milk are rich source of vitamin $B_6$. It is derivative of pyridoxine. Pyridoxine is white crystalline substance and is sensitive to light and UV radiation.

The three forms of vitamin $B_6$ are converted to pyridoxal phosphate which act as coenzyme in various enzymatic reactions involved in amino acid metabolism such as transamination decarboxylation, racemization and in metabolism of glycogen and fatty acids. Deficiency results dermatitis anemia.

**Vitamin $B_7$:** Also known as Biotin. Yeast, liver, kidney, milk are among richest source of vitamin $B_7$. Usually it occurs in bonded form called Biocytin. Biotin consists of fused imidazole and thiophene ring with fatty acid side chain.

Biotin crystallizes as long needles. It is heat stable and resistant to acids and alkalis. This vitamin is Coenzyme for enzyme catalyzing $CO_2$ fixation in organic molecules. Deficiency results in dermatitis, decrease is weight, hair loss etc.

**Vitamin $B_9$:** Commonly called as Liver Lactobacillus casei factor. It is found in salmon, dates, spinach root vegetables etc. Chemically it is also called as folic acid consists of 3 units: glutamic acid, $\beta$-amino benzoic acid and derivative of hetero cyclic fused ring compound. It is yellow Crystalline Substance, stable to heat, in alkaline or neutral conditions reduced from DHFA is dihydrofolic acid or $FH_2$ act as coenzymes associated with oxidation of NADPH to NADP Vitamin $B_9$ group is also involved in one carbon metabolism. Deficiency diseases are anemia in chicks, in man leads to megaloblastic anemia, glossitis etc.

**Vitamin $B_{12}$:** Commonly called as anti pernicious anemia factor (APA) and chemically is known as Cyanocobalamin, chief sources are milk, meat, eggs, fish. It has tetrapyrrole ring structure with co atom in its trivalent state.

Vitamin $B_{12}$ Coenzyme is 5 – deoxyadinosyl Cobalamine, It is the only known Coenzyme with carbon metal bond in a bio-molecule.

Coenzyme $B_{12}$ serves as carrier of methyl group to appropriate acceptor, it is associated with isomerisation of dicarboxylic acid. It also affects myelin formation. Deficiency diseases include juvenile pernicious anemia, adult pernicious anemia.

**Q.8 Write short note on Vitamin C?**

**Ans.:** It is commonly called as ascorbate; citrus fruits (like orange and lemon) are good sources of vitamin C. Not synthesized by primates. It is derivative of hexose called L-gulose. Chemically it is also known as ascorbic acid.

It is colorless, odorless, crystalline substance. Ascorbic acid function in many activities e.g.; formation tissue collagen, Vitamin C help in conversion of folic acid to tetra hydrofolic acid and also play important role in tyrosine metabolism. A vitaminosis C leads to scurvey or bleeding gums, anemia, delayed wound healing, tender bones, edematous swellings etc.

**Q.9 What are Choline and inositol?**

**Ans.:** Choline is also included in vitamins. The riches sources are egg yolk, liver, meats, cereals, vegetables like beans, peanuts. It is important constituent of lecithin.

It is quaternary ammonium compound and is water soluble. It undergoes esterification with acetyl CoA to form acetyl choline which is a Neurotransmitter, deficiency leads to haemorrhages in kidneys, fatty livers in rates.

**Ionositol:** Found in muscle, liver, kidney, brain and tissues of eye. In plants it occurs in fruits, vegetables. It occurs in four forms; ionositol, phytin, phophatidyl inositol and nondialzyable complex ionositol.

Ionositol is Corboxylic hexahydric alcohol, Myoinositol found in muscles is biologically active. It is sweet in taste and soluble in water. It is essential for transport processes in cells.

Deficiency results in retarted growth however its deficiency does not occur in man.

□ □ □

# B.Sc. /M.Sc. (Part I) Examination, 2011

**(Faculty of Science)**

**(Common to Three and Five Year Integrated Course)**

BIOTECHNOLOGY

Paper BT- 302

## BIOCHEMISTRY-I

***Year-2011***

***Time Allowed: 3 Hours*** ***Max. Marks: 50***

***Attempt five questions in all, including Question No.1 which is compulsory, selecting ONE question from each Section.***

1. Answer the following questions in short:-
   (i) What is the major constituent of living beings?
   (ii) What functions do "Lysosomes" play in the cell?
   (iii) Define Co-factors and Coenzymes.
   (iv) What is Chargaff's law?
   (v) Who discovered repetitive DNA?
   (vi) Who are CAM plants?
   (vii) How much angel is formed between two bonds in a structure of water molecule?
   (viii) How much angle is formed between two O-H bonds in a structure of water molecule?
   (ix) What is the difference between nucleoside and nucleotide?
   (x) What are Vitamins? 1 x 10 =10

**Section-A**

2. Describe the structure, chemical organization and functions of plasma membrane. 3+4+3=10
3. Write notes on:
   (i) Bacterial and Plant Cell Walls.

(ii) Golgi bodies.

(iii)Endoplasmic reticulum. 4+3+3=10

**Section-B**

4. Explain the biological significance of water. 10
5. Write an essay on Bio-molecules. 10

**Section-C**

6. What is mitochondria? Give an illustrated account of reactions and importance of Kreb's cycle. 3+5+2=10
7. Write notes on:
   (a) Structure and function of various part of nucleus.
   (b) DNA Replication 5+5=10

**Section-D**

8. What are chloroplasts? Explain "light" and "dark" reactions of photosynthesis. 3+7=10
9. Write Classification of enzymes and explain reaction and derivation of Michaelis-Menten equation kinetics. 5+5=10

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# Key Terms

**A form**. A duplex DNA structure with right-handed twisting in which the planes of the base pairs are tilted about 70° with respect to the helix axis.

**Acetal**. The product formed by the successive condensation of two alcohols with a single aldehyde. It contains two ether-linked oxygens attached to a central carbon atom.

**Acetyl CoA**. Acetyl-coenzyme A, a high-energy ester of acetic acid that is important both in the tricarboxylic acid cycle and in fatty acid biosynthesis. **Active site**. The region of an enzyme molecule that contains the substrate binding site and the catalytic site for converting the substrate(s) into product(s).

**Active transport**. The energy-dependent transport of a substance across a membrane.

**Adenine**. A purine base found in DNA or RNA.

**Adenosine**. A purine nucleoside found in DNA, RNA, and many cofactors.

**Adenosine diphosphate (ADP)**. The nucleotide formed by adding a pyrophosphate group to the 5'-OH group of adenosine.

**Adenosine triphosphate (ATP)**. The nucleotide formed by adding yet another phosphate group to the pyrophosphate group on ADP.

**Adenylate cyclase**. The enzyme that catalyzes the formation of cyclic 3',5' adenosine monophosphate (cAMP) from ATP.

**Adipocyte**. A specialized cell that functions as a storage depot for lipid.

**Aerobe**. An organism that utilizes oxygen for growth.

**Affinity chromatography**. A column chromatographic technique that employs attached functional groups that have a specific affinity for sites on particular proteins.

**Alcohol**. A molecule with a hydroxyl group attached to a carbon atom.

**Aldehyde**. A molecule containing a doubly bonded oxygen and a hydrogen attached to the same carbon atom.

**Alleles**. Alternative forms of a gene.

**Allosteric enzyme**. An enzyme whose active site can be altered by the binding of a small molecule at a nonoverlapping site.

**Angstrom (Å)**. A unit of length equal to $10^{-10}$ m.

**Anomers**. The sugar isomers that differ in configuration about the carbonyl carbon atom. This carbon atom is called the anomeric carbon atom of the sugar.

**Antibiotic**. A natural product that inhibits bacterial growth (is bacteriostatic) and sometimes results in bacterial death (is bacteriocidal).

**Antibody**. A specific protein that interacts with a foreign substance (antigen) in a specific way.

**Anticodon**. A sequence of three bases on the transfer RNA that pair with the bases in the corresponding codon on th messenger RNA.

**Antigen**. A foreign substance that triggers antibody formation and is bound by the corresponding antibody.

**Antiparallel b-pleated sheet (b-sheet)**. A hydrogen bonded secondary structure formed between two or more extended polypeptide chains.

**Autoradiography**. The technique of exposing film in the presence of disintegrating radioactive particles. Used to obtain information on the distribution of radioactivity in a gel or a thin cell section.

**B form**. The most common form of duplex DNA, containing a right-handed helix and about 10 (10.5 exactly) base pairs per turn of the helix axis.

**Beta-bend (b-bend) or turn**. A characteristic way of turning an extended polypeptide chain in a different direction, involving the minimum number of residues, and held together by hydrogen bonding.

**Beta-sheet (b-sheet)**. A sheetlike structure formed by the interaction between two or more extended polypeptide chains.

**Beta-oxidation (b-oxidation)**. Oxidative degradation of fatty acids that occurs by the successive oxidation of the b-carbon atom.

**Base**. The adenine, guanine, cytosine or thymine group attached to a nucleotide or nucleoside. Also may be used to refer to a nucleic acid unit within a polynucleotide chain, as when a gene is said to be 2000 bases long.

**Base analog**. A compound, usually a purine or a pyrimidine, that differs somewhat from a normal nucleic acid base.

**Base stacking**. The close packing of the planes of base pairs, commonly found in DNA and RNA structures.

**Bidirectional replication**. Replication in both directions away from the origin, as opposed to replication in one direction only (unidirectional replication).

**Bilayer**. A double layer of lipid molecules with the hydrophilic ends oriented outward, in contact with water, and the hydrophobic parts oriented inward.

**Bile salts**. Derivatives of cholesterol with detergent properties that aid in the solubilization of lipid molecules in the digestive tract.

**Biochemical pathway**. A series of enzyme-catalyzed reactions that results in the conversion of a precursor molecule into a product molecule.

**Biomolecule** : A biomolecule is any molecule that is produced by a living organism, including large macromolecules such as proteins, polysaccharides, lipids, and nucleic acids.

**Bond energy**. The energy required to break a bond.

**Buffer**. A conjugate acid-base pair that is capable of resisting changes in pH when acid or base is added to the system. This tendency will be maximal when the conjugate forms are present in equal amounts.

**cAMP**. 3',5' cyclic adenosine monophosphate. The cAMP molecule plays a key role in metabolic regulation

**Carbohydrate**. A polyhydroxy aldehyde or ketone.

**Carboxylic acid**. A molecule containing a carbon atom attached to a hydroxyl group and to an oxygen atom by a double bond.

**Carcinogen**. A chemical that can cause cancer.

**Carotenoids**. Lipid-soluble pigments that are made from isoprene units.

**Catabolism**. That part of metabolism that is concerned with degradation reactions.

**Catabolite repression**. The general repression of transcription of genes associated with catabolism that is seen in the presence of glucose.

**Catalyst**. A compound that lowers the activation energy of a reaction without itself being consumed.

**Catalytic site**. The site of an enzyme involved in the catalytic process.

**cDNA**. Complementary DNA, made in vitro from the mRNA by the enzyme reverse transcriptase using deoxyribonucleotide triphosphates. Unlike mRNA, cDNA can be easily propagated and sequenced.

**Cell commitment**. That stage in a cell's life when it be comes committed to a certain line of development.

**Cell cycle**. All of those stages that a cell passes through from one cell generation to the next.

**Cell line**. An established clone originally derived from a whole organism through a long process of cultivation.

**Cell lineage**. The pedigree of cells resulting from binary fission.

**Cell wall**. A tough outer coating found in many plant, fungal, and bacterial cells that accounts for their ability to withstand mechanical stress or abrupt changes in osmotic pressure. Cell walls always contain a carbohydrate component and frequently also a peptide and a lipid component.

**Chelate**. A molecule that contains more than one binding site and frequently binds to another molecule through more than one binding site at the same time.

**Chlorophyll**. A green photosynthetic pigment that is made of a magnesium dihydroporphyrin complex.

**Chloroplast**. A chlorophyll-containing photosynthetic organelle, found in eukaryotic cells, that can harness light energy.

**Chromatin**. The nucleoprotein fibers of eukaryotic chromosomes.

**Chromatography**. A procedure for separating chemically similar molecules. Segregation is usually carried out on paper or in glass or metal columns with the help of different solvents. The paper or glass columns contain porous solids with functional groups that have limited affinities for the molecules being separated.

**Chromosome**. A thread-like structure, visible in the cell nucleus during metaphase, that carries the hereditary information.

**Chromosome puff**. A swollen region of a giant chromosome; the swelling reflects a high degree of transcription activity.

**Cis dominance**. Property of a sequence or a gene that exerts a dominant effect on a gene to which it is linked.

**Cistron**. A genetic unit that encodes a single polypeptide chain.

**Citric acid cycle**. See tricarboxylic acid (TCA) cycle.

**Coactivator**. A molecule that functions together with a protein apoactivator. For example, cAMP is a coactivator of the CAP protein.

**Codon**. In a messenger RNA molecule, a sequence of three bases that represents a particular amino acid.

**Coenzyme**. An organic molecule that associates with enzymes and affects their activity.

**Cofactor**. A small molecule required for enzyme activity. It could be organic in nature, like a coenzyme, or inorganic in nature, like a metallic cation.

**Complementary base sequence**. For a given sequence of nucleic acids, the nucleic acids that are related to them by the rules of base pairing.

**Configuration**. The spatial arrangement in which atoms are covalently linked in a molecule.

**Conformation**. The three-dimensional arrangement adopted by a molecule, usually a complex macromolecule. Molecules with the same configuration can have more than one conformation.

**Consensus sequence**. In nucleic acids, the "average" sequence that signals a certain type of action by a specific protein. The sequences actually observed usually vary around this average.

**Cytidine**. A pyrimidine nucleoside found in DNA and RNA.

**Cytochromes**. Heme-containing proteins that function as electron carriers in oxidative phosphorylation and photosynthesis.

**Cytokinin**. A plant hormone produced in root tissue.

**Cytoplasm**. The contents enclosed by the plasma (or cytoplasmic) membrane, excluding the nucleus.

**Cytosine**. A pyrimidine base found in DNA and RNA.

**Cytosol**. The liquid portion of the cytoplasm, including the macromolecules but not including the larger structures like subcellular organelles or cytoskeleton.

**D loop**. An extended loop of single-stranded DNA displaced from a duplex structure by an oligonucleotide.

**Dalton**. A unit of mass equivalent to the mass of a hydrogen atom ($1.66 \times 10^{-24}$ g)

**Dark reactions**. Reactions that can occur in the dark, in a process that is usually associated with light, such as the dark reactions of photosynthesis.

**De novo pathway**. A biochemical pathway that starts from elementary substrates and ends in the synthesis of a biochemical.

**Deamination**. The enzymatic removal of an amine group, as in the deamination of an amino acid to an alpha keto acid.

**Dehydrogenase**. An enzyme that catalyzes the removal of a pair of electrons (and usually one or two protons) from a substrate molecule.

**Denaturation**. The disruption of the native folded structure of a nucleic acid or protein molecule; may be due to heat, chemical treatment, or change in pH.

**Density-gradient centrifugation**. The separation, by centrifugation, of molecules according to their density, in a gradient varying in solute concentration.

**Dialysis**. Removal of small molecules from a macromolecule preparation by allowing them to pass across a semipermeable membrane.

**Diauxic growth**. Biphasic growth on a mixture of two carbon sources in which one carbon source is used up before the other one. For example, in the presence of glucose and lactose, *E. coli* will utilize the glucose before the lactose.

**Difference spectra**. Plots comparing the absorption spectra of a molecule or an assembly of molecules in different states, for example, those of mitochondria under oxidizing or reducing conditions.

**Differential centrifugation**. Separation of molecules and/or organelles by sedimentation rate.

**Differentiation**. A change in the form and pattern of a cell and the genes it expresses as a result of growth and replication, usually during development of a multicellular organism. Also occurs in microorganisms (e.g. in sporulation).

**Dimer**. Structure resulting from the association of two subunits.

**Diploid cell**. A cell that contains two chromosomes (2N) of each type.

**Dipole**. A separation of charge within a single molecule.

**Disulfide bridge**. A covalent linkage formed by oxidation between two cysteine SH groups either in the same polypeptide chain or in different polypeptide chains. Reversible by adding reducing agents.

**DNA**. Deoxyribonucleic acid. A polydeoxyribonucleotide in which the sugar is deoxyribose; the main repository of genetic information in all cells and most viruses.

**DNA cloning**. The propagation of individual segments of DNA as clones.

**DNA library**. A mixture of clones, each containing a cloning vector and a segment of DNA from a source of interest.

**DNA polymerase**. An enzyme that catalyzes the formation of 3'-5' phosphodiester bonds from deoxyribonucleotide triphosphates.

**Domain**. A segment of a folded protein structure showing conformational integrity. A domain could include the entire protein or just a fraction of the protein. Some proteins, such as antibodies, contain many structural domains.

**Dominant**. Describing an allele whose phenotype is expressed regardless of whether the organism is homozygous or heterozygous for that allele.

**Double helix**. A structure in which two helically-twisted polynucleotide strands are held together by hydrogen bonding and base stacking.

**Duplex**. Same as double helix.

**Electrophoresis**. The movement of particles in an electrical field. A commonly-used technique for analysis of mixtures of molecules in solution according to their electrophoretic mobilities.

**Elongation factors**. Protein factors uniquely required during the elongation phase of protein synthesis. Elongation factor G (EF-G) brings about the movement of the peptidyl tRNA from the A site to the P site of the ribosome.

**Eluate**. The fluid that has passed through (eluted from) a chromatographic column.

**Endergonic reaction**. A reaction with a positive standard free energy change.

**End-product (feedback) inhibition**. The inhibition of the first enzyme in a pathway by the end product of that pathway.

**Endocrine glands**. Specialized tissues whose function is to synthesize and secrete hormones.

**Endonuclease**. An enzyme that breaks a phosphodiester linkage at some point within a polynucleotide chain.

**Endopeptidase**. An enzyme that breaks a polypeptide chain at an internal peptide linkage.

**Endoplasmic reticulum**. A system of double membranes in the cytoplasm that is involved in the synthesis of transported proteins. The rough endoplasmic reticulum has ribosomes associated with it. The smooth endoplasmic reticulum does not.

**Energy charge**. The fractional degree to which the AMP-ADP-ATP system is filled with high-energy phosphates (phosphoryl groups).

**Enhancer**. A DNA sequence that can stimulate transcription at an appreciable distance from the site where it is located. It acts in either orientation and either upstream or downstream from the promoter.

**Entropy**. The randomness of a system.

**Enzyme**. A moleucle, most often a protein, that contains a catalytic site for a biochemical reaction.

**Epimers**. Two stereoisomers with more than one chiral center that differ in configuration at one of their chiral centers.

**Equilibrium**. The point at which the concentrations of two compounds are such that the interconversion of one compound into the other compound does not result in any change in free energy.

***Escherichia coli (E. coli)***. A Gram negative bacterium commonly found in the vertebrate intestine. It is the bacterium most frequently used in the study of biochemistry and genetics.

**Eukaryote**. A cell or organism that has a membrane-bound nucleus.

**Excision repair**. DNA repair in which a damaged region is replaced.

**Excited state**. An energy-rich state of an atom or a molecule, produced by the absorption of radiant energy.

**Exergonic reaction**. A chemical reaction that takes place with a negative change in standard free energy.

**Exon**. A segment within a gene that carries part of the coding information for a protein.

**Exonuclease**. An enzyme that breaks a phosphodiester linkage at one or the other end of a polynucleotide chain so as to release single or small nucleotide residues.

**Facultative aerobe**. An organism that can use molecular oxygen in its metabolism but that also can live anaerobically.

**Fatty acid**. A long-chain hydrocarbon containing a carboxyl group at one end. Saturated fatty acids have completely saturated hydrocarbon chains. Unsaturated fatty acids have one or more carbon-carbon double bonds in their hydrocarbon chains.

**Feedback inhibition**. See end-product inhibition.

**Fermentation**. The energy-generating breakdown of glucose or related molecules by a process that does not require molecular oxygen.

**Fingerprinting**. The characteristic two-dimensional paper chromatogram obtained from the partial hydrolysis of a protein or a nucleic acid.

**Fluorescence**. The emission of light by an excited molecule in the process of making the transition from the excited state to the ground state.

**Frameshift mutations**. Insertions or deletions of genetic material that lead to a shift in the translation of the reading frame. The mutation usually leads to nonfunctional proteins.

**Free energy**. That part of the energy of a system that is available to do useful work.

**G1 phase**. That period of the cell cycle in which preparations are being made for chromosome duplication, which takes place in the S phase.

**G2 phase**. That period of the cell cycle between S phase and mitosis (M phase).

**Gametes**. The ova and the sperm, haploid cells that unite during fertilization to generate a diploid zygote.

**Gel fitration chromatography**. A technique that makes use of certain polymers that can form porous beads with varying pore sizes. In columns made from such beads, it is possible to separate molecules, which cannot penetrate beads of a given pore size, from small molecules that can. Also called gel-exclusion or molecular seive chromatography.

**Gene**. A segment of the genome that codes for a functional product.

**Gene amplification**. The duplication of a particular gene within a chromosome two or more times.

**Gene splicing**. The cutting and rejoining of DNA sequences.

**General recombination**. Recombination that occurs between homologous chromosomes at homologous sites.

**Generation time**. The time it takes for a cell to double its mass under specified conditions.

**Genetic map**. The arrangement of genes or other identifiable sequences on a chromosome.

**Genome**. The total genetic content of a cell or a virus.

**Genotype**. The genetic characteristics of an organism (distinguished from its observable characteristics, or phenotype).

**Globular protein**. A folded protein that adopts an approximately globular shape. May also be called soluble proteins.

**Gluconeogenesis**. The production of sugars from nonsugar precursors such as lactate or amino acids. Applies more specifically to the production of free glucose by vertebrate livers.

**Glycogen**. A polymer of glucose residues in 1,4 linkage, with 1,6 linkages at branchpoints.

**Glycogenic**. Describing amino acids whose metabolism may lead to gluconeogenesis.

**Glycolipid**. A lipid containing a carbohydrate group.

**Glycolysis**. The catabolic conversion of glucose to pyruvate with the production of ATP.

**Glycoprotein**. A protein linked to an oligosaccharide or a polysaccharide. Glycosaminoglycans. Long, unbranched polysaccharide chains composed of repeating disaccharide subunits in which one of the two sugars is either N-acetylglucosamine or N-acetylgalactosamine.

**Glycosidic bond**. The bond between a sugar and an alcohol. Also the bond that links two sugars in disaccharides, oligosaccharides, and polysaccharides.

**Glyoxylate cycle**. A pathway that uses some of the enzymes of the TCA cycle and some enzymes whereby acetate can be converted into succinate and carbohydrates.

**Glyoxysome**. An organelle containing some enzymes of the glyoxylate cycle

**Golgi apparatus**. A complex series of double-membrane structures that interact with the endoplasmic reticulum and that serve as a transfer point for proteins destined for other organelles, the plasma membrane, or extracellular transport.

**Gram molecular weight**. For a given compound, the weight in grams that is numerically equal to its molecular weight.

**Ground state**. The lowest electronic energy state of an atom or a molecule.

**Growth factor**. A substance that must be present in the growth medium to permit eucaryotic cell proliferation.

**Growth fork**. The region on a DNA duplex molecule where synthesis is taking place. It resembles a fork in shape, since it consists of a region of duplex DNA connected to a region of unwound single strands.

**Guanine**. A purine base found in DNA or RNA.

**Guanosine**. A purine nucleoside found in DNA and RNA.

**Hairpin loop**. A single-stranded complementary region of DNA or RNA that folds back on itself and base-pairs into a double helix.

**Half-life**. The time required for the disappearance of one half of a substance.

**Haploid cell**. A cell containing only one chromosome of each type.

**Heavy isotopes**. Forms of atoms that contain greater numbers of neutrons than the most common form (e.g., $^{15}N$, $^{13}C$).

**Helix**. A spiral structure with a repeating pattern.

**Heme**. An iron-porphyrin complex found in hemoglobin and cytochromes. Hemiacetal. The product formed by the condensation of an aldehyde with an alcohol; it contains one oxygen linked to a central carbon in a hydroxyl fashion and one oxygen linked to the same central carbon by an ether linkage.

**Henderson-Hasselbalch equation**. An equation that relates the pKa, to the pH and the ratio of the proton acceptor ($A^-$) and the proton donor (HA) species of a conjugate acid base pair.

**Heterochromatin**. Highly condensed regions of chromosomes that are not usually transcriptionally active.

**Heteroduplex**. An annealed duplex structure between two DNA strands that do not show perfect complementarity. Can arise by mutation, recombination, or the annealing of complementary single-stranded DNAs.

**Heteropolymer**. A polymer containing more than one type of monomeric unit.

**Heterotroph**. An organism that requires preformed organic compounds for growth.

**Heterozygous**. Describing an organism (a heterozygote) that carries two different alleles for a given gene.

**Hexose**. A sugar with a six-carbon backbone.

**High-energy compound**. A compound that undergoes hydrolysis with a high negative standard free energy change.

**Histones**. The family of basic proteins that is normally associated with DNA in most cells of eukaryotic organisms.

**Holoenzyme**. An intact enzyme containing all of its subunits and any necessary cofactors with full enzymatic activity.

**Homologous chromosomes**. Chromosomes that carry the same pattern of genes, but not necessarily the same alleles.

**Homopolymer**. A polymer composed of only one type of monomeric building block.

**Homozygous**. Describing an organism (a homozygote) that carries two identical alleles for a given gene.

**Hormone**. A chemical substance made in one cell and secreted so as to influence the metabolic activity of a select group of cells located at other sites in the organism.

**Hormone receptor**. A protein that is located on the cell membrane or inside the responsive cell and that interacts specifically with the hormone.

**Host cell**. A cell used for growth and reproduction of a virus.

**Hybrid (or chimeric) plasmid**. A plasmid that contains DNA from two different organisms.

**Hydrogen bond**. A weak, noncovalent, attractive force between one electronegative atom and a hydrogen atom that is covalently linked to a second electronegative atom.

**Hydrolysis**. The cleavage of a molecule by the addition of water. Hydrophilic. Preferring to be in contact with water.

**Hydrophobic**. Preferring not to be in contact with water, as is the case with the hydrocarbon portion of a fatty acid or phospholipid chain.

**Hydrophobic effect**. The noncovalent association of nonpolar groups with each other in aqueous solution.

**Hydroxyapatite**. A calcium phosphate gel used, in the case of nucleic acids, to selectively absorb duplex DNA-RNA from a mixture of single-stranded and duplex nucleic acids.

**Icosahedral symmetry**. The symmetry displayed by a regular polyhedron that is composed of 20 equilateral triangular faces with 12 corners.

**Imine**. A molecule containing a nitrogen atom attached to a carbon atom by a double bond. The nitrogen is also covalently linked to a hydrogen. Immunofluorescence. A cytological technique in which a specific fluorescent antibody is used to label an antigen. Frequently used to determine the location of an antigen in a tissue or a cell.

**Immunoglobulin**. A protein made in a B plasma cell and usually secreted; it interacts specifically with a foreign agent. Synonymous with antibody. It is composed of two heavy and two light chains linked by disulfide bonds. Immunoglobulins can be divided into five classes (IgG, IgM, IgA, IgD, and IgE) based on their heavy-chain component.

**Inducible proteins**. Those which are synthesized in different amounts depending on cellular signals.

***In vitro***. Literally, "in glass," describing whatever happens in a test tube or other receptacle, as opposed to what happens in whole cells of the whole organism (*in vivo*).

**Induced fit**. A change in the shape of an enzyme that results from the binding of substrate.

**Inducers**. Molecules that cause an increase in a protein activity when added to cells.

**Initiation factors**. Those protein factors that are specifically required during the initiation phase of protein synthesis.

**Intron**. A segment of the nascent transcript that is removed by splicing. Also refers to the corresponding region in the DNA. Synonymous with intervening sequence.

**Inverted repeat**. A chromosome segment that is identical to another segment on the same chromosome except that it is oriented in the opposite direction.

**Ion-exchange resin**. A polymeric resinous substance, usually in bead form, that contains fixed groups with positive or negative charge. An anion exchange resin has positively-charged groups and is therefore useful in exchanging the anionic groups in a test sample; a cation exchange resin is itself negatively charged, and has the opposite application. The resin is usually used in a column chromatographic procedure.

**Isoelectric point or pH**. The pH at which a protein has no net charge.

**Isomerase**. An enzyme that catalyzes an intramolecular rearrangement.

**Isomerization**. Rearrangement of atomic groups within the same molecule without any loss or gain of atoms.

**Isozymes**. Multiple forms of an enzyme that differ from one another in one or more of the properties.

**Ketone**. A functional group of an organic compound in which a carbon atom is double-bonded to an oxygen. Neither of the other substituents attached to the carbon is a hydrogen. Otherwise the group would be called an aldehyde.

**Ketone bodies**. Refers to acetoacetate, acetone, and b-hydroxybutyrate made from acetyl-CoA in the liver and used for energy in nonhepatic tissue.

**Ketosis**. A condition in which the concentration of ketone bodies in the blood or urine is unusually high.

**Kilobase**. One thousand bases in a DNA molecule.

**Kinase**. An enzyme catalyzing phosphorylation of an acceptor molecule, usually with ATP serving as the phosphate (phosphoryl) donor.

**Law of mass action**. The finding that the rate of a chemical reaction is a function of the product of the concentrations of the reacting species.

**Leader region**. The region of an mRNA between the 5' end and the initiation codon for translation of the first polypeptide chain.

**Leader sequence**. An N-terminal signal sequence that directs secretion and processing of proteins.

**Lectins**. Agglutinating proteins usually extracted from plants.

**Ligand**. A (usually small) molecule that binds to another, such as oxygen when it binds to myoglobin.

**Ligase**. An enzyme that catalyzes the joining of two molecules together. In DNA it joins 5'-OH to 3' phosphates.

**Lipid**. A biological molecule that is soluble in organic solvents. Lipids include steroids, fatty acids, prostaglandins, terpenes, and waxes.

**Lipid bilayer**. Model for the structure of the cell membrane based on the interaction between the hydrophobic regions of phospholipids.

**Lipopolysaccharide**. Usually refers to a unique glycolipid found in Gram negative bacteria.

**Lyase**. An enzyme that catalyzes the removal of a group to form a double bond, or the reverse reaction.

**Lysosome**. An organelle that contains hydrolytic enzymes designed to break down proteins that are targeted to that organelle.

**Lytic infection**. A virus infection that leads to the Iysis of the host cell, yielding progeny virus particles.

**Membrane**. A sheet-like composite of protein and lipid that is the boundary of cells and organelles.

**Membrane protein**. A protein that is associated with a membrane, rather than found free in the cell. A membrane protein may be integral (embedded or buried) in the membrane, or peripheral (attached more loosely, by interactions with either lipid or intergral membrane proteins).

**Membrane transport**. The facilitated transport of a molecule across a membrane.

**Merodiploid**. An organism that is diploid for some but not all of its genes.

**Mesosome**. An invagination of the bacterial cell membrane.

**Messenger RNA (mRNA)**. The template RNA carrying the message for protein synthesis.

**Metabolic turnover**. A measure of the rate at which already existing molecules of the given species are replaced by newly-synthesized molecules of the same type. Usually isotopic labeling is required to measure turnover.

**Metabolism**. The sum total of the enzyme-catalyzed reactions that occur in a living organism.

**Metamorphosis**. A change of form, especially the conversion of a larval form to an adult form.

**Metaphase**. That stage in mitosis or meiosis when all of the chromosomes are lined up on the equator (i.e., an imaginary line that bisects the cell).

**Micelle**. An aggregate of lipids in which the polar head groups face outward and the hydrophobic tails face inward; no solvent is trapped in the center.

**Michaelis constant (Km)**. The substrate concentration at which an enzyme-catalyzed reaction proceeds at one-half of the maximum velocity.

**Michaelis-Menten equation** (also known as the Henri-Michaelis-Menten equation). An equation relating the reaction velocity to the substrate concentration of an enzyme.

**Microtubules**. Thin tubules, made from globular proteins, that serve multiple purposes in eukaryotic cells.

**Mismatch repair**. The replacement of a base in a heteroduplex structure by one that forms a Watson-Crick base pair.

**Missense mutation**. A change in which a codon for one amino acid is replaced by a codon for another amino acid.

**Mitochondrion**. An organelle, found in eukaryotic cells, in which oxidative phosphorylation takes place. It contains its own genome and unique ribosomes to carry out protein syn thesis of only a fraction of the proteins located in this organelle.

**Nascent RNA**. The initial transcripts of RNA, before any modification or processing.

**Negative control**. Repression of biological activity by the presence of a specific molecule.

**Nernst equation**. An equation that relates the redox potential to the standard redox potential and the concentrations of the oxidized and reduced form of the couple.

**Nuclease**. An enzyme that cleaves phosphodiester bonds of nucleic acids.

**Nucleic acids**. Polymers of the ribonucleotides or deoxyribonucleotides.

**Nucleohistone**. A complex of DNA and histone.

**Nucleolus**. A spherical structure visible in the nucleus during interphase. The nucleolus is associated with a site on the chromosome that is involved in ribosomal RNA synthesis.

**Nucleophilic group**. An electron-rich group that tends to attack an electron-deficient nucleus.

**Nucleosome**. A complex of DNA and an octamer of histone proteins in which a small stretch of the duplex is wrapped around a molecular bead of histone.

**Nucleoside**. An organic molecule containing a purine or pyrimidine base and a five-carbon sugar (ribose or deoxyribose).

**Nucleotide**. An organic molecule containing a purine or pyrimidine base, a five-carbon sugar (ribose or deoxyribose), and one or more phosphate groups. A phosphoester of a nucleoside.

**Nucleus**. In eukaryotic cells, the centrally-located organelle that encloses most of the chromosomes. Minor amounts of chromosomal substance are found in some other organelles, most notably the mitochondria and the chloroplasts.

**Okazaki fragment**. A short segment of single-stranded DNA that is an intermediate in DNA synthesis. In bacteria, Okazaki fragments are 1000-2000 bases in length; in eukaryotes, 100-200 bases in length.

**Oligonucleotide**. A polynucleotide containing a small number of nucleotides. The linkages are the same as in a polynucleotide; the only distinguishing feature is the small size.

**Oligosaccharide**. A molecule containing a small number of sugar residues joined in a linear or a branched structure by glycosidic bonds.

**Oncogene**. A gene of cellular or viral origin that is responsible for rapid, unruly growth of animal cells. A cancer-causing gene.

**Operon**. A group of contiguous genes that are coordinately regulated by two cis-acting elements, a promoter and an operator. Found only in prokaryotic cells.

**Optical activity**. The property of a molecule that leads to rotation of the plane of polarization of plane-polarized light when the latter is transmitted through the substance. Chirality is a necessary and sufficient property for optical activity.

**Organelle**. A subcellular membrane-bounded body with a well-defined function.

**Osmotic pressure**. The pressure generated by the mass flow of water to that side of a membrane-bounded structure that contains the higher concentration of solute molecules. A stable osmotic pressure is seen in systems in which the membrane is not permeable to some of the solute molecules.

**Oxidation**. The loss of electrons from a compound.

**Oxidative phosphorylation**. The formation of ATP as the result of the transfer of electrons to oxygen.

**Oxido-reductase**. An enzyme that catalyzes oxidation-reduction reactions.

**Palindrome**. A sequence of bases that reads the same in both directions on opposite strands of the DNA duplex (e.g., GAATTC).

**PCR**. Polymerase chain reaction. A method for amplifying DNA sequences.

**Pentose**. A sugar with five carbon atoms.

**Pentose phosphate pathway**. The pathway involving the oxidation of glucose-6-phosphate to pentose phosphates and further reactions of pentose phosphates.

**Peptide**. An organic molecule in which a covalent amide bond is formed between the a-amino group of one amino acid and the a-carboxyl group of another amino acid, with the elimination of a water molecule. The resulting connection is called a peptide bond.

**Peptide mapping**. Same as fingerprinting.

**Peptidoglycan**. The main component of the bacterial cell wall, consisting of a two-dimensional network of heteropolysaccharides running in one direction, cross-linked with polypeptides running in the perpendicular direction.

**Periplasm**. The region between the inner (cytoplasmic) membrane and the cell wall or outer membrane of a bacterium.

**Permeable**. The property of allowing material to pass through, as a permeable membrane.

**Permease**. A protein that catalyzes the transport of a specific small molecule across a membrane.

**Peroxisomes**. Subcellular organelles that contain flavin-requiring oxidases and that regenerate oxidized flavin by reaction with oxygen.

**Phenotype**. The observable trait(s) that result from the genotype in cooperation with the environment.

**Phenylketonuria**. A human disease caused by a genetic deficiency in the enzyme that converts phenylalanine to tyrosine. The immediate cause of the disease is an excess of phenylalanine, which can be alleviated by a diet low in phenylalanine.

**Pheromone**. A hormone-like substance that acts as an attractant.

**Phosphodiester**. A molecule containing two alcohols esterified to a single molecule of phosphate. For example, the backbone of nucleic acids is connected by 5'-3' phosphodiester linkages between the adjacent individual nucleotide residues.

**Phospholipid**. A lipid containing charged hydrophilic phosphate groups; a component of cell membranes.

**Phosphorylation**. The formation of a phosphate derivative of a biomolecule.

**Photosynthesis**. The biosynthesis that directly harnesses the chemical energy resulting from the absorption of light. Frequently used to refer to the formation of carbohydrates from $CO_2$ that occurs in the chloroplasts of plants or the plastids of photosynthetic microorganisms.

**Pitch length (or pitch)**. The number of base pairs per turn of a duplex helix.

**Plasma membrane**. The membrane that surrounds the cytoplasm.

**Polar group**. A hydrophilic (water-loving) group.

**Polyamine**. A hydrocarbon containing more than two amino groups.

**Polycistronic messenger RNA**. In prokaryotes, an RNA that contains two or more cistrons; note that only in prokaryotic mRNAs can more than one cistron be utilized by the translation system to generate individual proteins.

**Polymerase**. An enzyme that catalyzes the synthesis of a polymer from monomers.

**Polynucleotide**. A chain structure containing nucleotides linked together by phosphodiester (5'-3') bonds. The polynucleotide chain has a directional sense with a 5' and a 3' end.

**Polynucleotide phosphorylase**. An enzyme that polymerizes ribonucleotide diphosphates. No template is required.

**Polypeptide**. A linear polymer of amino acids held together by peptide linkages. The polypeptide has a directional sense, with an amino- and a carboxy-terminal end.

**Polyribosome (polysome)**. A complex of an mRNA and two or more ribosomes actively engaged in protein synthesis.

**Polysaccharide**. A linear or branched chain structure containing many sugar molecules linked by glycosidic bonds.

**Porphyrin**. A complex planar structure containing four substituted pyrroles covalently joined in a ring and frequently containing a central metal atom. For example, heme is a porphyrin with a central iron atom.

**Positive control**. A system that is turned on by the presence of a regulatory protein.

**Post translational modification**. The covalent bond changes that occur in a polypeptide chain after it leaves the ribosome and before it becomes a mature protein.

**Primary structure**. In a polymer, the sequence of monomers and the covalent bonds. In proteins, it refers to the amino acid sequence.

**Primer**. A structure that serves as a growing point for polymerization. Short primers of DNA are often used in sequencing and mutagenesis procedures.

**Primosome**. A multiprotein complex that catalyzes synthesis of RNA primer at various points along the DNA template.

**Prokaryote**. A unicellular organism that contains a single chromosome, no nucleus, no membrane-bound organelles, and has characteristic ribosomes and biochemistry.

**Promoter**. That region of the gene that signals RNA polymerase binding and the initiation of transcription.

**Prophase**. The stage in meiosis or mitosis when chromosomes condense and become visible as refractile bodies.

**Proprotein**. A protein that is made in an active form, so that it requires processing to become functional.

**Prostaglandin**. An oxygenated eicosanoid that has a hormonal function. Prostaglandins are unusual hormones in that they usually have effects only in that region of the organism where they are synthesized.

**Prosthetic group**. Synonymous with coenzyme except that a prosthetic group is usually more firmly attached to the enzyme it serves.

**Protein subunit**. One of the components or monomers of a multicomponent protein.

**Proteoglycan**. A protein-linked heteropolysaccharide in which the heteropolysaccharide is usually the major component.

**Protist**. A relatively undifferentiated organism that can survive as a single cell.

**Proton acceptor**. A functional group capable of accepting a proton from a proton donor molecule.

**Proton motive force (Dp)**. The thermodynamic driving force for proton translocation.

**Proto-oncogene**. A cellular gene that can undergo modification to a cancer-causing gene (oncogene).

**Purine**. A heterocyclic ring structure with varying functional groups. The purines adenine and guanine are found in both DNA and RNA.

**Pyranose**. A simple sugar containing the six-membered pyran ring.

**Pyrimidine**. A heterocyclic six-membered ring structure. Cytosine and uracil are the main pyrimidines found in RNA, and cytosine and thymine are the main pyrimidines found in DNA.

**Pyrophosphate**. A molecule formed by two phosphates in anhydride linkage.

**Quaternary structure**. In a protein, the way in which the different folded subunits interact to form the multisubunit protein.

**R group**. Shorthand for the side chain of an amino acid.

**R loop**. A triple-stranded structure in which RNA displaces a DNA strand by DNA-RNA hybrid formation in a region of the DNA

**Recombination**. The transfer to offspring of genes not found together in either of the parents.

**Redox couple**. An electron donor and its corresponding oxidized form.

**Redox potential (E)**. The relative tendency of a pair of molecules to release or accept an electron. The standard redox potential ($E^0$) is the redox potential of a solution containing the oxidant and reductant of the couple at standard concentrations.

**Regulatory enzyme**. An enzyme in which the active site is subject to regulation by factors other than the enzyme substrate. The enzyme frequently contains a nonoverlapping site for binding the regulatory factor that affects the activity of the active site.

**Regulatory gene**. A gene whose principal product is a protein designed to regulate the synthesis of other genes.

**Renaturation**. The process of returning a denatured structure to its original native structure, as when two single strands of DNA are reunited to form a regular duplex, or an unfolded polypeptide chain is returned to its normal folded three-dimensional structure.

**Repair synthesis**. DNA synthesis following excision (cutting out) of damaged DNA.

**Repetitive DNA**. A DNA sequence that is present in many copies per genome.

**Replica plating**. A technique in which an impression of a culture is taken from a master plate and transferred to a fresh plate. The impression can be of bacterial clones or phage plaques.

**Replication fork**. The Y-shaped region of DNA at the site of DNA synthesis; also called a growth fork.

**Replicon**. A genetic element that behaves as an autonomous replicating unit. It can be a plasmid, phage, or bacterial chromosome.

**Repressor**. A regulatory protein that inhibits transcription from one or more genes. It can combine with an inducer (resulting in specific enzyme induction) or with an operator element (resulting in repression).

**Resonance hybrid**. A molecular structure that is a hybrid of two structures that differ in the locations of some of the electrons. For example, the benzene ring can be drawn in two ways, with double bonds in different positions. The actual structure of benzene is in-between these two equivalent structures.

**Restriction-modification system**. A pair of enzymes found in most bacteria (but not eukaryotic cells). The restriction enzyme recognizes a certain sequence in duplex DNA and makes one cut in each unmodified DNA strand at or near the recognition sequence. The modification enzyme methylates (or modifies) the same sequence, thus protecting it from the action of the restriction enzyme.

**Reverse transcriptase**. An enzyme that synthesizes DNA from an RNA template, using deoxyribonucleotide triphosphates.

**Rho factor**. A protein involved in the termination of transcription of some messenger RNAs.

**Ribose**. The five-carbon sugar found in RNA.

**Ribosomal RNA (rRNA)**. The RNA parts of the ribosome.

**Ribosomes**. Small cellular particles made up of ribosomal RNA and protein. They are the site, together with mRNA, of protein synthesis.

**RNA (ribonucleic acid)**. A polynucleotide in which the sugar is ribose.

**RNA polymerase**. An enzyme that catalyzes the formation of RNA from ribonucleotide triphosphates, using DNA as a template.

**RNA splicing**. The excision of a segment of RNA, followed by a rejoining of the remaining fragments.

**Rolling circle replication**. A mechanism for the replication of circular DNA. A nick in one strand allows the 3' end to be extended, displacing the strand with the 5' end, which is also replicated, to generate a double-stranded tail that can become larger than the unit size of the circular DNA.

**Salting in**. The increase in solubility that is displayed by typical globular proteins upon the addition of small amounts of certain salts, such as ammonium sulfate.

**Salting out**. The decrease in protein solubility that occurs when salts such as ammonium sulfate are present at high concentrations.

**Salvage pathway**. A family of reactions that permits, for instance, nucleosides as well as purine and pyrimidine bases resulting from the partial breakdown of nucleic acids to be re-utilized in nucleic acid synthesis.

**Satellite DNA**. A DNA fraction whose base composition differs from that of the main component of DNA, as revealed by the fact that it bands at a different density in a CsCI gradient. Usually repetitive DNA or organelle DNA.

**Second messenger**. A diffusible small molecule, such as cAMP, that is formed at the inner surface of the plasma membrane in response to a hormonal signal.

**Secondary structure**. In a protein or a nucleic acid, any repetitive folded pattern that results from the interaction of the corresponding polymeric chains. In proteins, the most common are b-strands (sheets) and a-helices.

**Semiconservative replication**. Duplication of DNA in which the daughter duplex carries one old strand and one new strand.

**Semipermeable**. The characteristic of allowing only some molecules, usually smaller or uncharged ones, to pass through.

**Sigma factor**. A subunit of RNA polymerase that recognizes specific sites on DNA for initiation of RNA synthesis.

**Signal sequence**. A (usually N-terminal) sequence of a protein that directs its processing or localization within the cell.

**Single-copy DNA**. A region of the genome whose sequence is present only once per haploid complement.

**Steroids**. Compounds that are derivatives of a tetracyclic structure composed of a cyclopentane ring fused to a substituted phenanthrene nucleus.

**Structural domain**. An element of protein tertiary structure that forms an independent folding unit.

**Structural gene**. A gene encoding the amino acid sequence of a polypeptide chain.

**Structural protein**. A protein that serves a structural function.

**Substrate**. A molecule that is acted upon, and chemically changed, by an enzyme.

**Subunit**. Individual polypeptide chains in a protein.

**Supercoiled DNA**. Supertwisted, covalently-closed duplex DNA.

**Template**. A polynucleotide chain that serves as a surface for the absorption of monomers of a growing polymer and thereby dictates the sequence of the monomers in the growing chain.

**Termination factors**. Proteins that are exclusively involved in the termination reactions of protein synthesis on the ribosome.

**Terpenes**. A diverse group of lipids made from isoprene precursors.

**Tertiary structure**. In a protein or nucleic acid, the final folded form of the polymer chain.

**Tetramer**. Structure resulting from the association of four subunits.

**Thymidine**. One of the four nucleosides found in DNA.

**Thymine**. A pyrimidine base found in DNA.

**Topoisomerase**. An enzyme that changes the extent of supercoiling of a DNA duplex.

**Transcription**. RNA synthesis that occurs on a DNA template.

**Transduction**. Genetic exchange in bacteria that is mediated via phage.

**Transfection**. An artificial process of infecting cells with naked viral DNA.

**Transfer RNA (tRNA)**. Any of a family of low-molecular weight RNAs that transfer amino acids from the cytoplasm to the template for protein synthesis on the ribosome.

**Transferase**. An enzyme that catalyzes the transfer of a molecular group from one molecule to another.

**Transformation**. Genetic exchange in bacteria that is mediated via purified DNA. In somatic cell genetics the term is also used to indicate the conversion of a normal cell to one that grows like a cancer cell.

**Transgenic**. Describing an organism that contains transfected DNA in the germ line.

**Transition state**. The activated state in which a molecule is best suited to undergoing a chemical reaction.

**Translation**. The process of reading a messenger RNA sequence for the specified amino acid sequence it contains.

**Transport protein**. A protein whose primary function is to transport a substance from one part of the cell to another, from one cell to another, or from one tissue to another.

**Tricarboxylic acid (TCA) cycle**. The cyclical process whereby acetate is completely oxidized to CO2 and water, and electrons are transferred to $NAD^+$ and flavine. The TCA cycle is localized to the mitochondria in eukaryotic cells and to the plasma membrane in prokaryotic cells. Also called the Krebs or citric acid cycle.

**Trypsin**. A proteolytic enzyme that cleaves (cuts) peptide chains next to the basic amino acids arginine and Iysine

**Ultracentrifuge**. A high-speed centrifuge that can attain speeds up to 60,000 rpm and centrifugal fields of 500,000 times gravity. Useful for characterizing and/or separating macromolecules.

**Unwinding proteins**. Proteins that help to unwind double-stranded DNA during DNA replication.

**UV irradiation**. Electromagnetic radiation with a wavelength shorter than that of visible light (200-390 nm). Causes damage to DNA (mainly by forming pyrimidine dimers).

**van der Waals forces**. Refers to the combined effect of two types of interactions, one attractive and one repulsive. The attractive forces are due to favorable interactions among the induced instantaneous dipole moments that arise from fluctuations in the electron charge densities of neighboring nonbonded atoms. Repulsive forces arise when noncovalently bonded atoms come too close together.

**Vitamin**. A trace organic substance required in the diet of some species. Many vitamins are precursors of coenzymes.

**Watson-Crick base pairs**. The type of hydrogen-bonded base pairs found in DNA, or comparable base pairs found in RNA. The base pairs are A-T, G-C, and A-U.

**Western blot**. Similar in principle to a Southern blot, but where the species adsorbed to the nitrocellulose filter is a protein, and the detection makes use of specific antibodies.

**Wild-type gene**. The form of a gene (allele) normally found in nature.

**Wobble**. A proposed explanation for base pairing that is not of the Watson-Crick type and that often occurs between the 3' base in the codon and the 5' base in the anticodon.

**X-ray crystallography**. A technique for determining the structure of molecules from the X-ray diffraction patterns that are produced by crystalline arrays of the molecules.

**Z form**. A duplex DNA structure in which there is the usual type of hydrogen bonding between the base pairs but in which the helix formed by the two polynucleotide chains is left-handed rather than right-handed.

**Zwitterion**. A dipolar ion with spatially-separated positive and negative charges. For example, most amino acids are zwitterions, having a positive charge on the a-amino group and a negative charge on the a-carboxyl group but no net charge on the overall molecule.

**Zygote**. A cell that results from the union of haploid male and female sex cells. Zygotes are diploid.

**Zymogen**. An inactive precursor of an enzyme. For example, trypsin exists in the inactive form trypsinogen before it is converted to its active form, trypsin.

# Top Ten Books for Biochemistry

1. Principles of Biochemistry by Lehninger, Nelson & Cox.
2. Biochemistry by Lubert Stryer, Berg and Tymoczko.
3. Fundamentals of Biochemistry by Voet, Voet & Pratt.
4. Biochemistry by Garrett & Grisham.
5. Harpers Illustrated Biochemistry by Robert K Murray , Daryl K Granner , Victor W Rodwell.
6. Lippincott's Illustrated Reviews Biochemistry, 5/e by Harvey.
7. Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson & John Walker (Eds.).
8. Fundamentals of Biochemistry by J.L.Jain.
9. Biochemistry by Geoffrey L. Zubay.
10. Text Book of Biochemistry by Dr. G. R. Agarwal, Dr. O. P.

# Notes

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