

## BIOCHEMISTRY AND CLINICAL PATHOLOGY

**SHORT QUESTION CARRY FOUR MARKS****Q. 1 What are proteins? Classify them with examples.****Ans:** Proteins are high molecular weight polypeptides containing amino acid joined together by peptide linkage (-CO-NH).**Classification of proteins:****1) Simple Proteins:** Simple protein yields only amino acids on hydrolysis.**a. Albumins:** Soluble in water, Coagulated by heat, Precipitated at high salt concentration.**b. Globulins:** Insoluble in water, Coagulated by heat, Precipitated at half saturated salt solutions.**2) Conjugated Proteins:** These contain simple protein molecules united with non-protein group and on hydrolysis they yield other non-proteinaceous substances in addition to amino acids.**a. Lipoproteins:** These are composed of lipids and proteins.**Ex:** Lipoprotein of egg yolk, milk, cell membrane & lipoprotein of bloods.

1. Very high density lipoproteins.

2. High density lipoproteins.

3. Low density lipoproteins.

4. Very low density lipoproteins.

**b. Nucleoproteins:** These are the conjugated proteins having proteins and nucleic acid. **Ex:** Ribosome, Nucleoproteins & Nucleohistones.**c. Metalloproteins:** These proteins are conjugated and proteins. **Ex:** Hemoglobin – with iron.**d. Phosphoproteins:** Contain phosphorus radical as prosthetic group. **Ex:** Caseinogens (milk), Ovovitellin (egg yolk).**e. Flavoproteins:** Contain riboflavin as a prosthetic group. **Ex:** Flavoproteins of liver & kidney.**3) Derived Proteins:** These are intermediate hydrolysis products, which are formed by the action of physical (heat), chemical or enzymatic agents on natural proteins.**Primary derivatives:** **Ex:** Proteans, Metaproteins, Coagulated proteins.**Secondary derivatives:** **Ex:** Proteoses, Peptones, Peptides.**Q. 2 Write short note on water balance.****Ans:** The body water is maintained within fairly constant limits by a regulation between the intake and output.

Water take ml per day	Water loss ml per day
Drinking 1000-1500ml	Urine 1000-1500ml
Water in food-700ml	Respiration 400ml
Water derived during metabolism of food-300ml.	Perspiration 400ml
	Stool 200ml
Total=2000-2500ml	Total=2000-2500ml

**Q. 3 Enumerate the biological function of magnesium, potassium, sodium, phosphorus, calcium, zinc & chlorine.****Ans: Biological Function of Magnesium:**

1. It is required for the formation of bone and teeth.

2. Magnesium serve as a co-factor for several enzymes with requiring ATP. **Ex:** Hexokinase glucokinase.

3. Magnesium is necessary for proper neuro muscular function.

**Biological Function of Potassium:**

1. potassium maintains intracellular osmotic pressure.
2. It is required for the regulation of acid-base balance and water balance in the cell.
3. It plays an important role in cardiac function.
4. Potassium is necessary in the transmission of nerve impulses.
5. Enzymes like pyruvate kinase require  $K^+$  as a co-factor.

**Q. 4 What are essential amino acids? Give examples and mention their significance. Ans:**

**Essential amino acids:** These are amino acids which are not synthesized in the body. So they must be supplied in adequate amounts through diet.

**The following are the eight essential amino acid:**

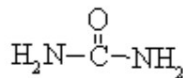
1. Tryptophan
2. Valine
3. Phenylalanine
4. Methionine
5. Lysine
6. Leucine
7. Threonine
8. Isoleucine

All these 8 amino acids are essential for normal growth and maintenance of nitrogen equilibrium. The nutritional value of a protein depends on the amount of essential amino acid present in it. Casein of milk contains all these essential amino acids. So it is a complete protein. Gliadin of maize lacks in tryptophan. So it is an incomplete protein.

**Q. 5 Describe Urea cycle & write its Significance.**

**Ans. Urea:** urea is the end product of protein metabolism or amino acid metabolism. The ammonia formed from amino acid nitrogen is toxic body. It is detoxified and converted to urea in urea cycle.

Urea molecule  
ammonia. The



contains amino groups; one of the nitrogen atoms of urea comes from other is transferred from amino acid aspartate.

**Significance:**

1. Ammonia formed in the biochemical transformation of amino acids this ammonia is highly toxic so, urea cycle of plays an important role in converting ammonia into harmless, non-toxic water soluble urea.
2. Any metabolic defects in urea cycle ultimately lead to build up in blood ammonia (Hyper ammonemia) lead to toxicity the clinical symptoms associated with defect in urea cycle enzymes include vomiting irritability mental retardation.
3. Increased and decreased blood urea level occur in number of disease the increase level is associated with kidney disease and decreased blood urea are rare and may be found in severe liver damage.



Ammonia ( $\text{NH}_4^+$ ) combines with  $\text{CO}_2$  (derived from decarboxylation) to form carbamyl phosphate catalyzed by the enzyme carbamyl phosphate synthetase of mitochondria. This step consumes two ATP and is irreversible.

Citrulline is synthesized from carbamyl phosphate and ornithine by ornithine trans carbamylase. ornithine is regenerated and used in urea cycle.

3. **Synthesis of argino succinate:** Argino succinate synthetase enzyme condenses Citrulline and aspartate to produce argino succinate. The second amino group is incorporated in this step. ATP is cleaved to AMP and pyrophosphate.

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**5. Cleavage of argino phosphate:**

Argino phosphate cleaves argino succinate to give arginine and fumarate. Fumarate is immediate precursor of urea and fumarate will enter into TCA cycle.

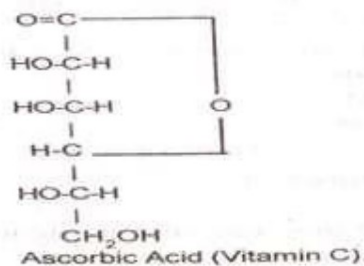
**6. Formation of urea:**

Arginase cleaves arginine to yield urea and ornithine, ornithine so generated enters mitochondria for its rise in the urea cycle.

**Q. 6 Give the source, biochemical role and deficiency symptoms of vitamin c.****Ans:**

**Vitamin C** is also called as ascorbic acid

**Source:** Amla, citrus fruits, tomatoes, green pepper, raw cabbage, cauliflower, grapes, apples, banana, milk, liver, green leafy vegetables, potatoes, papaya etc.

**Structure:****Functions:**

1. It involves in the oxidation and reduction reactions of the cell. Since it undergoes reversible oxidation.
2. It is involved in the conversion of folic acid to active tetrahydrofolic acid.
3. It is involved in the formation of the nor-epinephrine.
4. It is necessary for collagen synthesis.
5. It helps in iron absorption by converting ferric ion to ferrous ion.

**Deficiency diseases:** deficiency of vitamin c produces scurvy. The symptoms are:

1. Wide spread hemorrhage
2. Painful, swollen joints
3. Defective teeth formation
4. Defective bone formation.

**Requirement:** 75 to 100mg daily.

**Q. 7. Give the structure of sucrose, maltose along with test to identify them. Ans: Structure of sucrose and maltose:****sucrose****Test for identification of sucrose and maltose:**

**1) Benedict's test:** Collect 5ml of Benedict's solution in a tube boil to this hot solution add 4-5 drops of sample & again heat observe red ppt.

**2) Fehling's test:** In a clean tube mix equal volume of Fehling's A and Fehling's B solution and boil, To this hot solution add 5-8 drops of sample and heat observed red ppt. (If it is positive maltose and if it is negative sucrose)

**Q. 8 What is Transamination & Deamination of amino acids?****Ans: -TRANSMISSION:**

The transfer of an amino group (-NH<sub>2</sub>) from an amino acid to a keto acid is known as transamination. This reaction involves reversible transfer of a pair of amino acids and a pair of keto acids catalyzed by a group of enzymes transaminases (Amino transferases). This process is predominantly in liver.

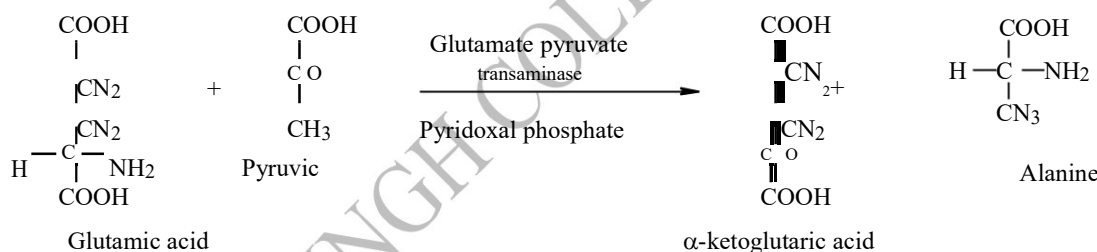
Pyridoxal phosphate is the co-enzyme essential for the transaminase activity. All the amino acids except lysine, proline hydroxy proline and thiamine can participate in the transamination reaction.

The keto acids participating in the transamination reaction are only three namely 2-ketoglutaric acid, oxaloacetic acid and pyruvic acid.

**Significance:**

1. Transamination diverts the excess amino acids towards energy production.
2. All the amino acids undergo of glutamate. In fact, glutamate is the only amino acid that undergoes oxidative deamination to a significant extent to liberate free NH<sub>3</sub> for urea synthesis in urea cycle.
3. SGPT: (Serum glutamate pyruvate transaminase); and SGOT (serum glutamate oxaloacetate transaminase). Have diagnostic importance the SGPT level increases in liver diseases like viral hepatitis, jaundice. SGOT level increases in myocardial infection.
4. In the cells, all the amino acids are available in a proportion for protein biosynthesis. Transamination is very important for the redistribution of amino group for protein biosynthesis and production of non-essential amino acids as per the requirement of the cell.

Examples:

**1. Non-oxidative deamination:**

Some of the amino acids can be deaminated to liberate NH<sub>3</sub> without undergoing oxidation.

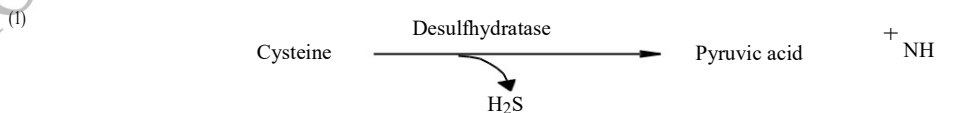
It is catalyzed by enzymes such as:

1. Dehydratases.
2. Desulfhydratases.

Dehydratase enzymes deaminate amino acids containing a hydroxyl group. E.g. Serine, threonine

Desulfhydrase enzymes deaminate amino acids containing sulphur. E.g. Cysteine

Example:

**3. DECARBOXYLATION:**

Decarboxylation is the removal of a carboxyl group (-COOH) from an amino acid to form an amine with removal of CO<sub>2</sub> is called as decarboxylation. These are catalyzed by the enzyme decarboxylase which requires pyridoxal phosphate as co-enzyme. Decarboxylase enzymes are available in liver, kidney and brain.

**Significance:**

Decarboxylation of an amino acid leads to the formation of biologically important amines that is.

**2. DIAMINATION:**

Deamination means removal of amino group from amino acid in the form of  $\text{NH}_3$ . The ammonia liberated is diverted from urea synthesis. The remaining carbon skeleton of amino acid is catabolised to keto acid.

Deamination can be:

(2) Oxidative, (2) Non-oxidative

**Significance:**

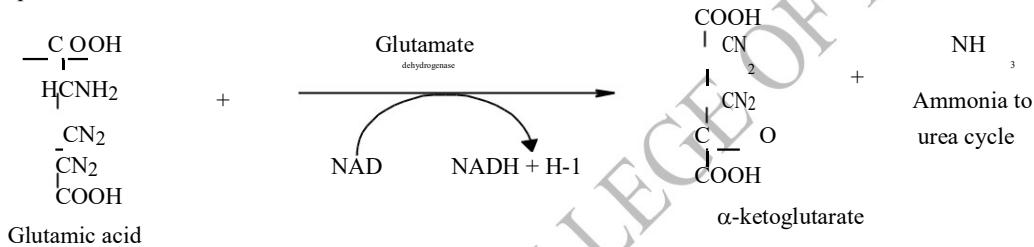
1. Deamination results in the liberation of ammonia for urea synthesis.
2. The deamination results or serves synthesis of non-essential amino acids.

**2. Oxidative deamination:**

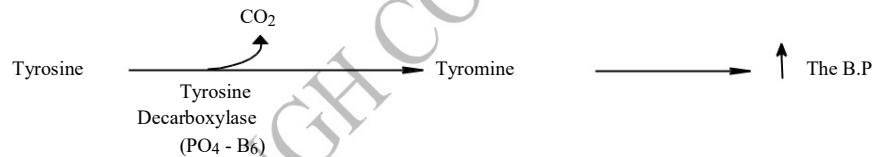
It is the removal of amino group from an amino acid which results in liberation of  $\text{NH}_3$  and formation of keto acid by undergoing oxidation that is in aerobic condition. Oxidative deamination is catalyzed by the enzyme such as

1. L-amino acid oxidases.
2. D-amino acid oxidases.
3. Glutamate dehydrogenase.

Example:



1. Tyrosine is decarboxylized to tyromine by the enzyme tyrosine decarboxylase causing deviation of B.P.



2. Histadine (A.A)  $\rightarrow$  Histamine (Amine)  $\rightarrow$  Affects B.P

3. 3,4, Dihydroxy phenyl alanine  $\rightarrow$  Dopamine  $\rightarrow$  Pressure of adrenaline and non-adrenaline

**Q. 9. Write note on diagnostic and therapeutic applications of enzymes.****Ans:**

**DIAGNOSTIC APPLICATION:** Some diseases can be diagnosed by the estimation of blood level of certain enzyme. Under normal conditions, the blood levels of these enzymes are low. But in certain diseases, the blood levels are more. It is due to release of these enzymes from damaged tissues or organs. So estimation of these enzymes in blood helps in the diagnosis of diseases.

Enzyme	Diseases that can be diagnosed
Amylase	Acute pancreatitis
Alkaline phosphate	Rickets
Creatinine phosphokinase	Myocardial infraction
Glutamic oxaloacetic transaminase(GO T)	Myocardial infraction
Glutamic pyruvic transaminase(GPT)	Liver diseases
Isocitrate dehydrogenase(IDH)	Hepatitis
Lactate dehydrogenase (LDH)	Myocardial infraction
Lipase	Acute pancreatitis

**Therapeutic applications:**

1. Enzymes like pepsin, papain and amylase are administered for improving digestion.
2. The enzyme hyaluronidase is used for diffusion of a number of drugs.
3. The enzymes streptokinase and urokinase are used for dissolving blood clot.
4. The enzyme trypsin is used for liquefying the lens. So it is used in the treatment of cataract.
5. The enzymes asparaginase is used for the treatment of cancer.

**Q. 10. What are carbohydrates? Classify them with examples.**

**Ans:** Carbohydrates are defined as polyhydroxy aldehydes or ketones, or compounds and their derivatives which on hydrolysis yield their monomer or polyhydric alcohol. The General formula for carbohydrates is  $C_x(H_2O)_y$ . Carbohydrates supply the major part of energy needed by the living cell.

**Classification of Carbohydrates:****1) Monosaccharide:**

These are simplest carbohydrates which cannot be hydrolyzed into simplest form, they divided into different sub-group basing on number of carbon atom they had also on functional group they contain.

**1. Trioses:** They have three carbon atoms.

**2. Tetroses:** They are monosaccharide which contains 4 carbon atoms. **E.g.** Erythrose – Aldotetrose  
Erythrulose – Ketotetrose.

**3. Pentose:** They are monosaccharide which contains 5 carbon atoms.

E.g. Ribose - Aldopentose.

Ribulose - Ketopentose.

**4. Hexoses:** They are monosaccharide which contains 6 carbon atoms. E.g. Glucose - Aldohexose

Fructose - Ketohexose.

**2) Oligosaccharides:** These contain 2 to 10 units of monosaccharide however most naturally occurring oligosaccharides are disaccharides. Oligosaccharides include disaccharides like Sucrose, Maltose, Lactose, etc..

E.g. **Sucrose:** It contains glucose and fructose sucrose also known as cane sugar.

**Maltose:** It is caused as malt sugar also. It contains two units of glucose.

**Lactose:** It contains glucose and galactose. It is also known as milk – sugar.

**3) Polysaccharides:** Carbohydrates that give many monosaccharides on hydrolysis are called polysaccharides.

E.g. **Starch:** it is reserve Polysaccharide present in plant starch acts as source of carbohydrates for human being.

**Cellulose:** Cellulose is present in wood and plants cellulose is not used as source of carbohydrates in humans because human beings have no enzyme to break. 1,4 glycoside bond present in cellulose acts as structural polysaccharide.

#### Classification of Polysaccharides:

**Homopolysaccharides:** Polysaccharides which on hydrolysis give only one type of monosaccharide are called homopolysaccharides. E.g. Starch, Glycogen, Cellulose.

**Heteropolysaccharides:** Polysaccharides which on hydrolysis give two or many type of monomers are called heteropolysaccharides. E.g. Agar, Alginate, Hemicellulose.

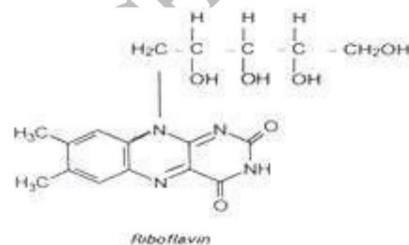
**Q.11 Describe the function, structure and deficiency disorder of riboflavin.**

**Ans:**

**RIBOFLAVIN** is also called as vitamin B<sub>2</sub>.

**Source:** milk, eggs, liver, kidney, green leafy vegetable, meat and fish.

**Structure:**



**Function:**

1. It involves in the regulatory functions of some hormones connected with carbohydrate metabolism.
2. It involves in the electron transport system in the mitochondria.
3. Intermediary metabolism as an enzyme called flavoproteins.

**Deficiency:** Cheilosis, glossitis

**Requirement:** 1.5 - 1.8mg daily

**Q. 12 Write a note on enzyme inhibition.**

**Ans:**

**Enzyme inhibitors** are substances which lower down the rate of enzyme reaction.

They produce their effect by acting on the co-enzyme.

**Enzyme inhibition is classified as:**

1. Competitive inhibition



2. Non competitive inhibition

3. Allosteric inhibition

**1. Competitive inhibition:** the inhibitor and the substrate have structural similarity.

So they both compete with each other to bind with the enzyme. The inhibitor is successful in this competition. So an enzyme inhibitor complex is formed. This complex cannot lead to the formation of a product.

**Ex:** The conversion of succinic acid to fumaric acid is catalysed by the enzyme succinic dehydrogenase. The reaction is inhibited by malonic acid which has a structural resemblance to succinic acid.

**2. Non competitive inhibition:** This type of inhibition does not involve competition between the substrate and the enzyme. The inhibitor affects the enzyme substrate complex and prevents its dissociation to release the product.

**Ex:** Enzymes with SH group are non-competitively inhibited by metal ions like  $\text{Ag}^{++}$  and  $\text{Hg}^{++}$

**3. Allosteric inhibition:** Allosteric site is a site other than the active site which is present in the enzyme. The inhibitor binds to the allosteric site and produces conformational changes in the enzymes. So the substrate cannot bind with the enzyme and a product cannot be formed. **Ex:** ATP is an allosteric inhibitor of hexokinase.

**Q. 13 Write a note on**

**Mutarotation. Ans:**

**Mutarotation** is defined as the change in the specific optical rotation representing the interconversion of  $\alpha$  and  $\beta$  forms of D- glucose to an equilibrium mixture.

**Ex:**  $\alpha\text{-D-glucose} \rightarrow \text{Equilibrium mixture} \leftarrow \beta\text{-D glucose} + 112.2^\circ + 52.5^\circ$   
 $+18.7^\circ$

This change in optical rotation is called as mutarotation. This occurs due to a change of one form of the drug to the other. i.e.,  $\alpha$  to  $\beta$  form and vice versa. The equilibrium mixture contains 63%  $\beta$ -anomer and 36%  $\alpha$ -anomer of glucose and 1% open chain.

**Q. 14 Explain denaturation of proteins.**

**Ans:**

**Denaturation** is defined as disruption of secondary, tertiary and quaternary structure of a protein. This leads to alteration in the physical and chemical properties of the affected protein. It should be noted that the primary structure is not affected.

**Agents which produce denaturation:**

1. Physical agents like heat, ultraviolet light, X-rays, high pressure and violet shaking of the protein solution.
2. Chemical agents like acids, alkalies, enzymes, heavy metal salts, organic solvents, urea and detergents.

**Physical changes:**

1. Solubility decreases
2. Viscosity increases
3. Surface tension is altered
4. Denaturated protein cannot be crystallized

**Chemical changes:**

Denaturation leads to splitting of linkages like hydrogen bond and disulfide bond in the protein molecule. This leads to unfolding and uncoiling of the peptide chain. As a result lose

their activity.

**Q. 15 Define and classify vitamins with examples.**

**Ans:** Vitamins are defined as organic compounds which are required in very small amounts and are essential for various biochemical reactions. The body cannot synthesize vitamins they must be provided by food. Their absence in food produces specific deficiency diseases.

**Classification of vitamins:**

**1. Fat soluble vitamins:** Vitamin A, D, E and K

**2. Water soluble vitamins:**

**a) B- complex group:** Thiamine(B<sub>1</sub>)

Riboflavin(B<sub>2</sub>)

Pantothenic acid(B<sub>3</sub>)

Niacin(B<sub>4</sub>), Pyridoxine(B<sub>6</sub>)

Biotin, Folic acid, Lipoic acid

Cyanocobalamine(B<sub>12</sub>)

**b) Ascorbic acid:** Vitamin C

**Q. 16 write a note on Glucose tolerance test**

**Answer -** Glucose tolerance test is done to know the ability of an individual respond in to maintain blood sugar homeostasis by giving or loading the glucose and the diabetes can be diagnosed the basis of glucose tolerance test.

In this test the person should be supplemental with carbohydrate rich food for at least 3 days

prior to the test and person should be avoid the exercise on the previous day of the test; the person should be fastened for overnight.

**Procedure:**

**β – Glucose**

**(Sp-rotation = +19°)**

**β – Glucose**

**(Sp-rotation = +19°)**

1. GTT should be conducted preferably in the morning (9-11am).
2. A fasting blood sample is drawn and urine is collected.
3. Person is given 75gms of glucose dissolved in about 300ml of water, to be drunk in about 5 minutes.
4. Blood and urine sample are collected at intervals of 30, 60, 90, 120 minutes.
5. The blood sample is analyzed for glucose concentration and urine sample are qualitatively tested for presence of glucose.
6. The fasting sample of urine is also tested of acetone.

**Q. 17 What are platelets? List out their functions**

**Answer: -** Platelets (Thrombocytes): - They are round or oval shaped cells with biconcave platelets do not have a nucleus but cytoplasm contains distinct granules. Platelets are synthesised by giant cells of bone marrow. They have an average life span of 5-10 days and are destroyed in the spleen.

The normal platelet count is 2-5 lakhs per cu mm of blood

**Functions of platelets**

1. Coagulation(blood clotting): - Platelets contain thrombokinase or thromboplastin. Which is liberated when platelets come in contact with rough surface and it plays an important role in clotting of blood
2. Vasoconstriction:- Histamine, norepinephrine and serotonin are liberated when the platelets are disintegrated, these substances have Vasoconstrictor activity and therefore

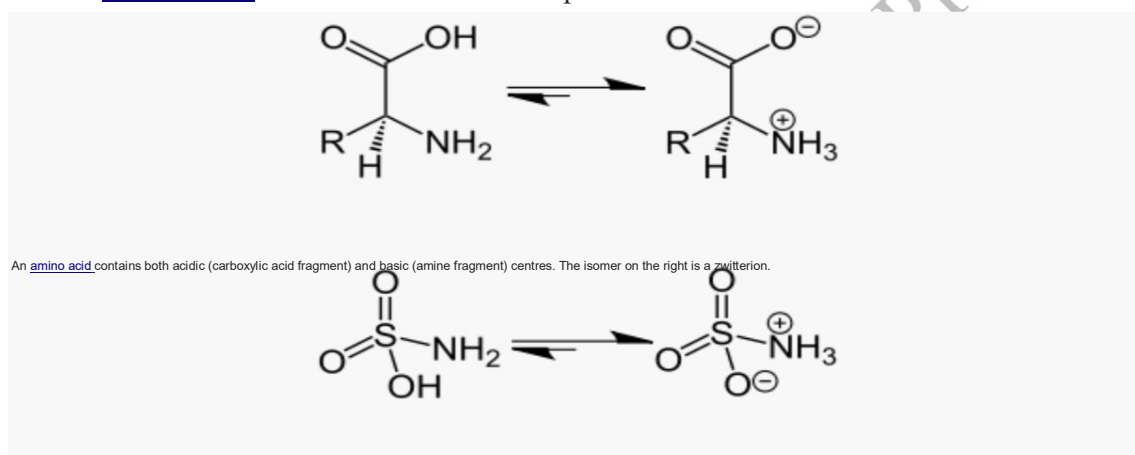
- play an important role in control of bleeding.
3. Platelets act in haemostatic mechanism by way of simultaneous clotting and agglutination resulting in cessation of blood from ruptured blood vessels.
  1. An important role in the arrest of bleeding
  2. Curing of wounds in the endothelial lining of the vessels promoting the clotting of blood and securing the firm of adhesion of the clot.

**Q. 18 Define a) Zwitter Ion, b) Isoelectric  $P^H$ , c) Saponification Number, d) Iodine Value**

**Answer**

- a) Zwitter Ion:** - Zwitter ion is a neutral molecule with a positive and a negative electrical charge, though multiple positive and negative charges can be present. Zwitterions are distinct from dipoles, at different locations within that molecule. Zwitterions are sometimes also called **inner salts**.

Amino acids are the best-known examples of zwitterions



- b) Isoelectric  $P^H$  :-** Isoelectric  $P^H$  is the pH at which a particular molecule carries no net electrical charge. The net charge on the molecule is affected by pH of its surrounding environment and can become more positively or negatively charged due to the gain or loss
- c) Saponification Number:** - It is defined as the number of milligrams of KOH or NaOH required to saponify 1gm of oil or fat

**Example**

Sl. No	Fat or oil	Saponification value
1	Butter fat	210-230 milligrams
2	Human fat	195-200 milligrams
3	Olive oil	185 – 195 milligrams
4	Linseed oil	188 – 195 milligrams

- d) Iodine number (Iodine value):-** It is defined as number of grams of iodine absorbed by 100gm of fat or oil.

**Iodine value of some oil or fats:**

1. Butter fat: 26 to 28gm
2. Human fat: 65 to 70 gm

**Significance:**

- It shows degree of unsaturation in oil and fat.
- Lower the iodine number less is the degree of unsaturation.

### Q.19 Define Epimers & Anomers of carbohydrates with examples

Answer: - In stereochemistry, **epimer** refers to one of a pair of stereoisomers. The two isomers differ in configuration at only one stereogenic center.

Example - The sugars glucose and galactose are epimers.

An **anomer** is a special type of epimer. It is one of two stereoisomers of a cyclic saccharide that differs only in its configuration at the hemiacetal or hemiketal carbon.

The two molecules pictured are both epimers and anomers (as indicated by the  $\alpha$  and  $\beta$  designation).

also called the **anomeric carbon**

$\alpha$ -D-glucopyranose	$\beta$ -D-glucopyranose

### Q. 20 Write a note on rancidity of oils

**Answer - Rancidity of fat and oils:** - When oils and fats are exposed to light, air, heat and moisture for a longer period of time resulting in an unpleasant odour and taste thus oil or fat is said to be rancid this phenomena is called as rancidification.

1. The bad and objectionable odor is because of liberation of volatile oil, fatty acids like butyric acids, caproic acid, and capric acid.

2. Rancidity is of two types.

**(a) Hydrolytic rancidity:** - Some oils and fats undergo hydrolysis and produce bad odour is called as hydrolytic rancidity.

**(b) Oxidative rancidity:** - If the rancidity caused due to oxidation of double bonds in fats and oils.

4. Rancidity can be prevented by addition of antioxidants like Vitamin-E, ascorbic acid

**Q. 21 Name the ketone bodies & explain the tests to detect them** **Answer:** - The acetones aceto active acid and  $\beta$ -hydroxy butyric acid are collectively referred to as ketone bodies. Increase in the accumulation of ketone bodies in blood tissue is known as ketosis.

**Ketone Bodies:** - Beta-hydroxybutyric Acid; Acetoacetate; Acetoacetic Acid; Acetone

**(a) Rothera Test:**

**PRINCIPLE:-** Ketone bodies react with sodium nitro prusside in presence of ammonia sulphate and ammonia to give purple colored complex.

**PROCEDURE:-** 5ml sample excess amount of ammonium sulphate mix well than add two

drops sodium nitro prusside mix well and add 1ml of ammonia along the sides and observe purple colored ring.

(b) Lugol Test:

PRINCIPLE:-Ketone bodies react with sodium nitro prusside of alkali to give red colour.

PROCEDURE:-2ml sample 2 drops sodium nitro prusside mix well and add 1ml NaOH observe red colour.

**a) What are erythrocytes? Write a note on anaemia & write the abnormalities of RBC's Answer**

Erythrocytes (RBC): - Erythrocytes are circular, biconcave, disc-shaped non-nucleated cells. It contains respiratory pigment (oxygen-carrying protein) haemoglobin which is a pigment that gives red color to the blood.

A healthy adult male has—5.4 millions per cu. mm of blood.

A healthy adult female has -4.8 million per cu. mm of blood.

**Functions of Erythrocytes:-**

1. Transport of gases: - Carriage of  $O_2$  &  $CO_2$  is the most important function of RBC. Oxygen carriage by Hb is called oxygenation. It is the only method of  $O_2$  transport from the lungs to tissues cell and carriage of  $CO_2$  from tissues cell to lungs for exhalation of  $CO_2$  as waste product.
2. Ionic balance:- RBC cell wall is selectively permeable to ions on either side. So it maintain balance between various anions(-) and cations in the blood.
3. Acid- base balance:- Hb content of RBC plays an important role as buffer. Its protein and potassium salts help the acid- base balancing process in the blood.

**Anemia** is a disease in which there is a reduction in oxygen carrying capacity of blood. Anemia is characterised by decreased number of RBC's or decreased concentration of haemoglobin.

The symptoms are weakness, breathlessness, intolerance to cold, loss of appetite, pale skin.

**Causes of anemia:**

- Due to excessive blood loss i.e. severe haemoglobin failure the function of red bone marrow so that no blood cell are formed.
- Due to increased destruction of RBC's by haemolysis.
- Dietary deficiency of iron may cause decreased RBC% causing anemia.
- Due to tuberculosis, malaria, typhoid, and other chronic infections like tonsillitis, rheumatoid arthritis etc.

- a. Polycythemia
- b. Anaemia
- c. Megaloblastic anaemia
- d. Sickle cell anaemia
- e. Pernicious anaemia
- f. Iron deficiency anaemia
- g. Haemolytic anaemia

**Write a note on atherosclerosis.**

**Answer: - Atherosclerosis** (also known as **arteriosclerotic vascular disease** or **ASVD**) is a specific form of arteriosclerosis in which an artery wall thickens as a result of invasion and accumulation of white blood cells (WBCs).

The accumulation of the WBCs is termed "fatty streaks" early on because of appearance

being similar to that of marbled steak. These accumulations contain both living, active WBCs (producing [inflammation](#)) and remnants of dead cells, including [cholesterol](#) and [triglycerides](#). The remnants eventually include calcium and other crystallized materials, within the outermost and oldest plaque. The "fatty streaks" reduce the elasticity of the artery walls. However, they do not affect blood flow for decades, because the artery muscular wall enlarges at the locations of plaque. The wall stiffening may eventually increase pulse pressure; widened pulse pressure is one possible result of advanced disease within the major arteries.

Atherosclerosis is therefore a [syndrome](#) affecting arterial [blood vessels](#) due to a chronic inflammatory response of WBCs in the walls of arteries. This is promoted by [low-density lipoproteins](#) (LDL, plasma proteins that carry [cholesterol](#) and [triglycerides](#)) without adequate removal of fats and cholesterol from the macrophages by functional [high-density lipoproteins](#) (HDL). It is commonly referred to as a "hardening" or furring of the arteries. It is caused by

the formation of multiple [atheromatous plaques](#) within the arteries

### **LONG QUESTIONS CARRYING FOURTEEN MARKS**

**What are coenzyme? Describe the chemistry source, biochemical role and deficiency symptoms of folic acid.**

**Ans:**

**Coenzymes** are non- protein organic compound are present in enzymes and associated with them. They are low molecular weight, thermostable and can be separated by dialysis.

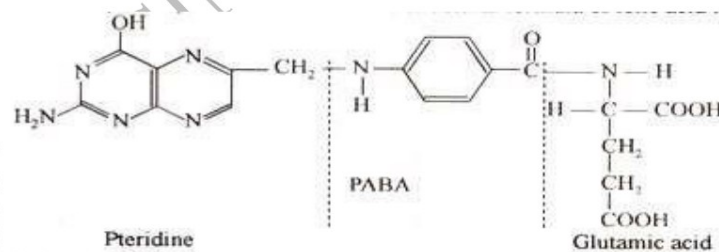
**Characteristic of co-enzymes:**

1. They are stable towards heat.
2. Generally derived from vitamins.
3. Functions as co-substrate.
4. They participate in various reaction like involving Transfer of atoms or group like hydrogen, aldehyde, keto, amino etc.

**FOLIC ACID:**

**Sources:** The richest sources are green leafy vegetables and other sources include-yeast, liver, kidney, meat, fish, milk, fruits etc.

**Structure:**





**Biochemical Role:**

1. Folic acid is also involved in the catabolism of histidine.
2. Folic acid and vit. B12 are required for the synthesis of R.B.C.s in the bone marrow.
3. Folic acid and vit. B12 are essential for normal growth of micro organisms.

**Deficiency manifestation:** The deficiency of folic acid may lead to megaloblastic anaemia.

**Requirements:** 400 µg per day

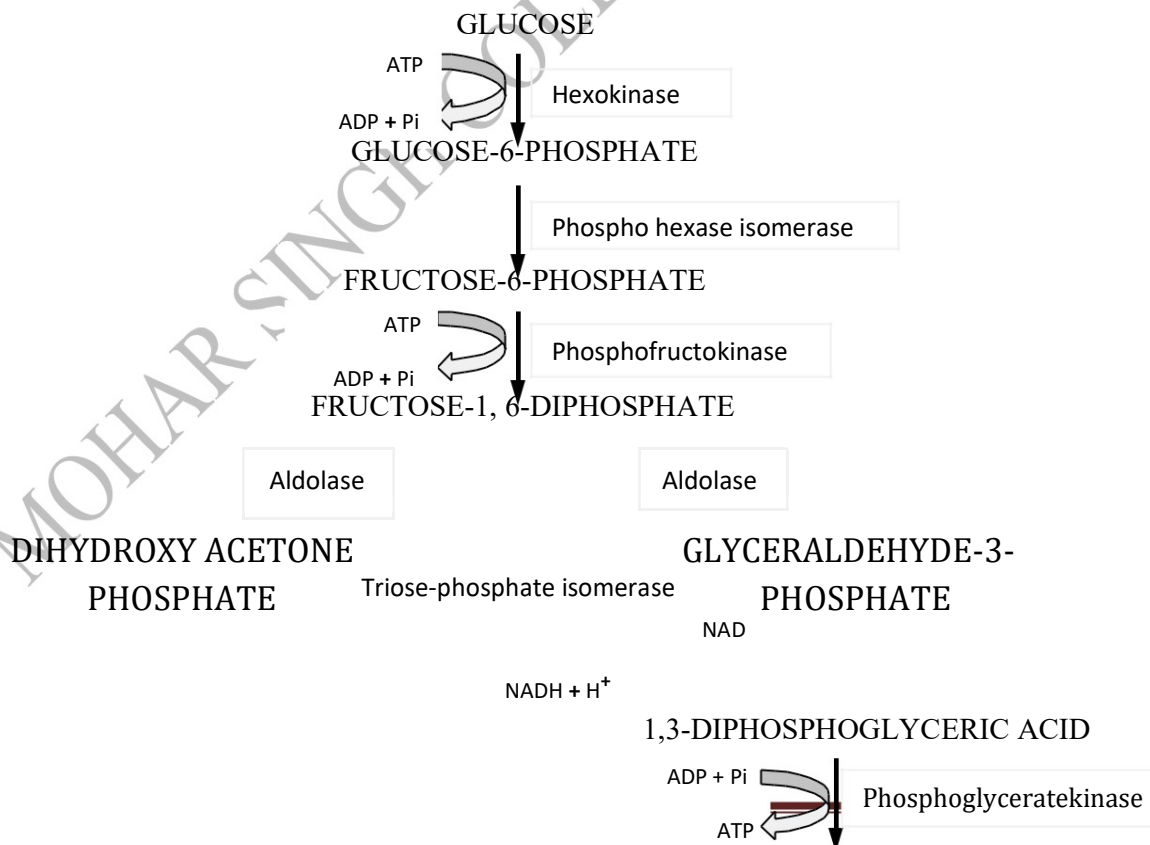
**Name the different pathway of carbohydrate metabolism. Describe the pathway involved in the oxidation of glucose.**

**Ans:**

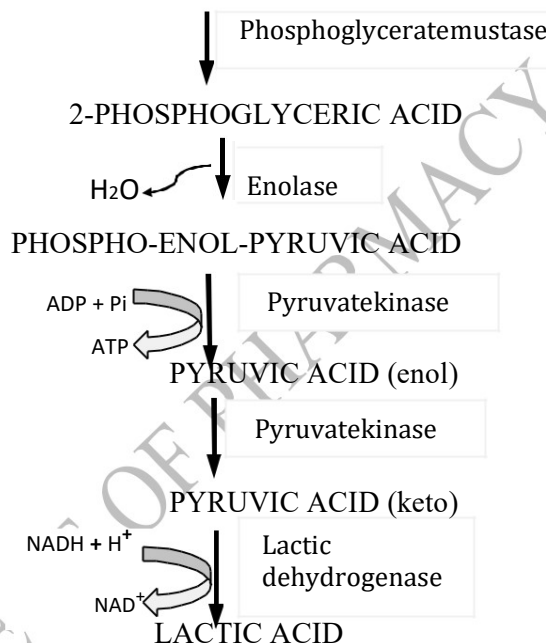
**Different pathways of carbohydrate metabolism are as follows:**

1. Glycolysis
2. Glycogenolysis
3. Glycogenesis
4. HMP shunt pathway
5. Gluconeogenesis
6. Citric acid cycle

**Glycolysis:** Glycolysis is a catabolic process, in which the glucose is catalysed by oxidation. The energy so obtained, is in the presence of oxygen i.e. anaerobically. Hence it is also called as 'anaerobic fermentation of glucose'. The oxidation of glucose to pyruvate and lactate is called glycolysis. It is also called as Embden Meyerhof pathway.



### 3-PHOSPHOGLYCERIC ACID



#### Reaction of glycolysis:

**1. Glucose to glucose -6-phosphate:** Reaction is catalysed by the enzymes hexokinase. ATP act as a phosphate donor. A magnesium ion is necessary. Reactions occur in liver, muscles. Reaction is irreversible.

**2. Glucose -6-phosphate to fructose-6-phosphate:** Catalysed by isomerase enzymes. ATP and ADP are necessary act as donor.

**3. Fructose-6-phosphate to Fructose-1-6-diphosphate:** Catalysed by enzyme phosphofructokinase.

**4. Fructose-1-6-diphosphate to glyceraldehydes-3-phosphate and dihydroxy acetone phosphate:** Catalysed by aldoses. Both are interconvertible. By phosphotriose isomerases.

**5. Glyceraldehyde-3-phosphate to 1-3-diphosphoglycerate:** Catalysed by enzymes glyceraldehydes-3-phosphate dehydrogenase. Reaction required NAD coenzymes. 6 molecule of ATP are formed as a result of this reaction

**6. 1-3-Diphosphoglycerate to 3-phosphoglycerate:** Catalysed by phosphoglycerate kinase enzymes. 2 molecules of ATP formed for each molecule of glucose.

**7. 3-phosphoglycerate to 2-phosphoglycerate:** Catalysed by enzymes phosphoglycerate mutase.

**8. Phosphoglycerate to phosphoenol pyruvate :** Catalyse by enzyme enolase.

**9. Phosphoenol pyruvate to enol pyruvate:** Catalysed by enzyme pyruvate kinase 2 molecule of ATP in this reaction for each molecule of glucose.

**10. Enol pyruvate to keto pyruvate:** Keto pyruvate is the keto form of pyruvic acid. This is a spontaneous reaction.

**11. Keto pyruvate to lactic acid:** occur when no oxygen is present (anaerobic conditions) catalysed by lactate dehydrogenases enzymes. Reduction of pyruvate to lactic acid. Hydrogen atom is donated by NADH. Lactic acid formed in aerobic condition. Pyruvic acid is the end product of glycolysis.



### Energetics of glycolysis:

Molecules of ATP utilized glucose to glucose-6-phosphate = 1

Fructose-6-phosphate to fructose-1,6-Diphosphate	= 1
<b>TOTAL</b>	<b>02</b>

### Molecules of ATP synthesized:

Glyceraldehyde-3-phosphate to 1,3-diphosphoglycerate = 6

1,3-diphosphoglycerate to 3-phosphoglycerate = 2

Phosphoenolpyruvate to enolpyruvate = 2

**TOTAL** **10**

No. of ATP synthesized = 10

No. Of ATP utilized = - 2

Net ATP synthesized = **08**

---

### Describe the colour reactions of protein and biological role of protein. **Ans:**

**1. Millon's Test:** This test is given by amino acid tyrosine. Tyrosine reacts with mercuric sulphate presented in Millon's reagent and produce Red ppt on heating.

**2. Xanthoproteic Test:** This test is given by aromatic amino acid and tyrosine, phenyl alanine and tryptophan. These reacts with  $\text{HNO}_3$  produces white precipitate. Changes to yellow colour on heating.

**3. Ninhydrin Test:** proteins on heating with ninhydrin solution produces a purple colour. This is due to the amino acid present in the proteins.

**4. Sakaguchi Test:** This is the specific test for amino acid Arginine. It gives a red colour with Sakaguchi reagent (this reagent contains alcoholic alpha naphthol and a drop of sodium)

**5. Lead acetate Test:** It is the specific test for sulphur containing amino acids on heating with strong alkali, the amino acids spits out sulphur which combines with lead acetate to form a black precipitate.

**6. Aldehyde Test:** This test is given by amino acid Tryptophan. In this test Tryptophan condenses with formaldehyde in the presence of  $\text{H}_2\text{SO}_4$  to form violet coloured compound.

### Biological role of protein:

1. Proteins provide structural frame work for the cells and tissue.
2. They act as enzymes and hormones.
3. Proteins can be catabolished to release energy.
4. Storage proteins bind with specific substance and store them. Ex:- Iron stored in the form of ferritin.
5. Some transport proteins carry specific substances across membrane or body fluid.
6. Protein exerts osmotic pressure which helps in maintaining electrolyte and water balance.
7. Proteins are amphoteric in nature and thus help in maintaining pH of the body.

### Discuss glycogenolysis and Glycogenesis with its significance. **Ans:**

**GLYCOGENOLYSIS:** It is the breakdown of glycogen to glucose. The breakdown of glycogen occurs in the liver and muscle .

GLYCOGEN

↓ combined action of phosphorylas  
And debranching enzyme

Glucose -1-phosphate

↓ phosphoglucomutase

glucose-6-phosphate

↓ Glucose-6-phosphatase

## GLUCOSE

### Reactions:

1. glycogen to glucose-1-phosphate:- catalysed by phosphorylase and debranching enzyme and release glucose.
2. glucose-1-phosphate to glucose-6-phosphate:- catalysed by phosphoglucomutase.
3. glucose-6-phosphate to glucose:- catalysed by enzyme glucose-6-phosphatase and releases inorganic phosphorous and water.

**Significance:** Glycogenolysis takes place in the cells of the muscle and liver tissues in response to hormonal and neural signals. glycogenolysis plays an important role in the fight- or-flight response and the regulation of glucose levels in the blood.

In myocytes (muscle cells), glycogen degradation serves to provide an immediate source of glucose-6-phosphate for glycolysis, to provide energy for muscle contraction. In hepatocytes (liver cells), the main purpose of the breakdown of glycogen is for the release of glucose into the bloodstream for uptake by other cells.

**Glycogenesis:** The formation of glycogen from glucose is called Glycogenesis. Glucose

↓Hexokinase

Glucose-6-phosphate

↓phosphoglucomutase

Glucose-1-phosphate

UTP↓UDPG pyrophosphorylase

UDP Glucose

↓glycogen Synthetase

Glycogen chain

↓branching enzyme

Glycogen with branched chains

### Reactions:

1. glucose to glucose-6-phosphate:- reaction catalysed by the enzyme hexokinase.
2. glucose-6-phosphate to glucose-1-phosphate:- it is catalysed by enzyme phosphoglucomutase
3. glucose-1-phosphate to uridine diphosphate glucose:- it is catalysed by UDPG pyrophosphorylase
4. UDPG to glycogen:- glucose of UDPG is added to an already existing glycogen molecule

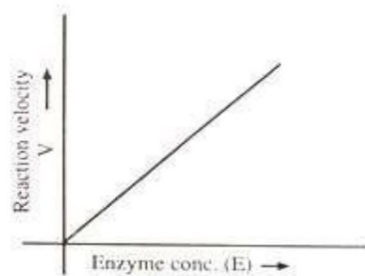
**Explain the factors affecting enzyme activity.**

**Ans:**

**1. Concentration of enzyme:-**

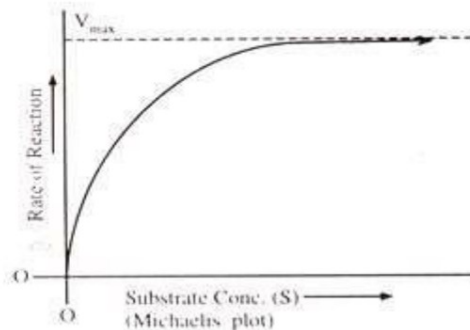
As the concentration of enzyme is Increased, The velocity of the Reaction also proportionally Increases:

Ex:- This property is used to determine the serum enzymes for the diagnosis of diseases.



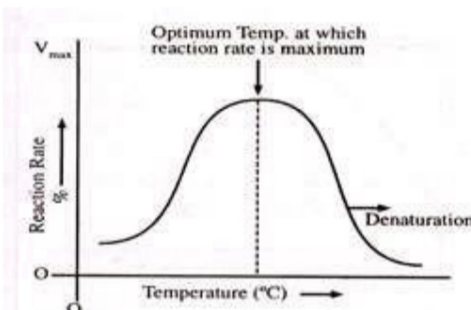
**2. Concentration of substrate:-**

As the substrate concentration increases gradually the Enzyme Reaction also Increases but upto limited Range after that it becomes constant.



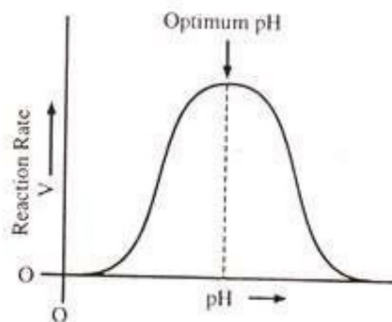
**3. Effect of temperature:-**

Velocity of an Enzyme Reaction Increases with Increase in Temperature upto a maximum and then declines. A Bell shaped Curve is usually observed. The optimum temperature for most of the enzyme is between  $40^{\circ}\text{C}$ - $45^{\circ}\text{C}$ . When the Enzyme are Exposed to a Temperature above  $50^{\circ}\text{C}$  denaturation will take place. Majority of the Enzymes Become inactive at higher Temperature above  $70^{\circ}\text{C}$ .



#### 4. Effect of pH:-

Each enzyme has an optimum PH at which the velocity is maximum. Below and above this pH, The Enzyme activity is much lower and at Extreme pH, The Enzyme Becomes Totally Inactive. Most the Enzymes shows optimum activity around Neutral pH(6-8).



#### 5. Effect of inhibitors:-

Presence of enzyme inhibitors reduces the enzyme action.

Heavy metals, are the inhibitors for enzyme activity.

#### 6. Enzyme activators:-

Presence of activators in certain concentration increases the enzyme activity i.e. cysteine HCL increases the proteolytic activity of papain.

#### 7. Effect of time:-

Under Ideal and optimal conditions the time Required for an Enzyme Reaction is less.

**Define & classify lipids with suitable examples. Write a note on Rancidity.**

Answer - Lipids are heterogeneous group of organic compounds related to fatty acids or are substances capable of forming such ester and are utilized by the living organism. Lipids are insoluble in water. Soluble in inorganic solvents, (like alcohol, ether etc)

Lipids are derived from Greek word 'lipos' which means fat.

#### Classification of lipids:

Lipids are classified are as follows:

##### 1. Simple lipids:

- (a) Oils and fat
- (b) Waxes

##### 2. Compound lipids:

- (a) Phospho lipids: e.g. Lecithins, cephalins, plasmalogens
- (b) Glycolipids: e.g. Cerebrosides, Gangliosides
- (c) Other compound lipids: Lipoproteins, Sulpholipids, Aminolipids

##### 3. Derived lipids:

E.g. Fatty acids, Glycerols, Sterols, Prostaglandins, Sphingolipids

**Rancidity of fat and oils:** When oils and fats are exposed to light, air, heat and moisture for a longer period of time resulting in an unpleasant odour and taste thus oil or fat is said to be rancid this phenomena is called as rancidification.

1. The bad and objectionable odor is because of liberation of volatile oil, fatty acids like butyric acids caproic acid capric acid.
2. Rancid oils show high acid types.

### Rancidity is of two types.

(a) **Hydrolytic rancidity:** Some oils and fats undergo hydrolysis and produce bad odour is called as hydrolytic rancidity.

(b) **Oxidative rancidity:** If the rancidity caused due to oxidation of double bonds in fats and oils.

Note - Rancidity can be prevented by addition of antioxidants like Vitamin-E, ascorbic acid

### Describe the normal & abnormal constituents of urine including their significance & laboratory tests to detect them.

Answer - Urine is the chief excretory fluid eliminated through kidney. Most of the waste products are eliminated through urine. Urine shows the presence of large number of organic & in-organic substances.

#### Normal Constituents of Urine

1. **Urea:-** It is main end product of protein metabolism. About 25-30gm of urea is excreted per 24 hrs.

##### Clinical Significance:

- In liver disease urea levels are increased
- In fever
- In Diabetes high urea levels observed.

#### Test for Urea:

3ml of urine sample + few drops of alkaline sodium hypobromate Solution (NaOBr).	Effervescence of Nitrogen.	Urea is present.
5ml of urine+ 4 drops of phenoptaline +	Solution becomes	Urea is present.
Pinch full of ureas powder & mix.	pink.	

2. **Uric acid:-** It is the end product of purine metabolism. About 0.7gm of acid excreted through urine per 24 hrs.

##### Clinical Significance:

- In gout kidney loses the power of eliminating uric acid properly. This leads to the deposition of uric acid in the joint.
- Excretion of uric acid is increased in leukemia.

#### Test for Uric Acid:

##### a) Schiff's test

Moisten a strip of filter paper with AgNO <sub>3</sub> solution add it drop or urine.	Black or Yellow brown stain formed	Uric acid is present.
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##### b) Benedict's Test:-

5ml. of urine+ 5 drops of Benedict's uric acid reagent + 3gms of anhydrous sodium carbonate (Na <sub>2</sub> CO <sub>3</sub> ) & Mix by shaking.	A deep blue color develops.	Uric acid is present.
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### 3. Creatinine:-

It is the product of the breakdown of creatine. About 1.7gm of Creatinine is excreted through urine per 24 hrs.

**Clinical Significance:**

- It increases in fasting & after high water ingestion.
- Increased amount are found in malnutrition, disintegration of muscular tissue & in carcinoma of the liver.
- Decreased level of Creatinine is found in anemia, paralysis, leukemia.

**Test for Creatinine:-**

**a) Jaffe's Test:**

5ml. of urine+ 1ml. of saturated solution of picric acid + 3gm. Of anhydrous $\text{Na}_2\text{CO}_3$ mix well by shaking.	A deep orange color is formed.	Creatinine is present.
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**b) Weyl's Test:-**

5ml. of urine+ 5 drops of sodium nitropruside+2ml. of 10% NaOH	Ruby red color is formed & soon changes to yellow.	Creatinine is present.
--	--	------------------------

**Abnormal Constituents of Urine:**

Substances which are not present in easily detectable amount in urine of normal healthy individuals, but present in urine under certain diseased conditions are said to be Abnormal or Pathological Constituents of urine.

**The Abnormal Constituents are:-**

1. Reducing sugars like glucose, fructose, lactose, and pentose.
2. Proteins like albumin, globulin.
3. Ketone bodies like Acetone, Acetoacetic acid, Beta - hydroxyl butyric acid.
4. Bile salts like sodium glycolate, sodium taracolate.
5. Bile pigments like bilirubin, biliverdin.
6. Blood
7. Pus

**Describe the following with help of chemical reaction**

- a) HMP Shunt Pathway
- b) Citric Acid Cycle
- c)  $\beta$ - oxidation of fatty acid

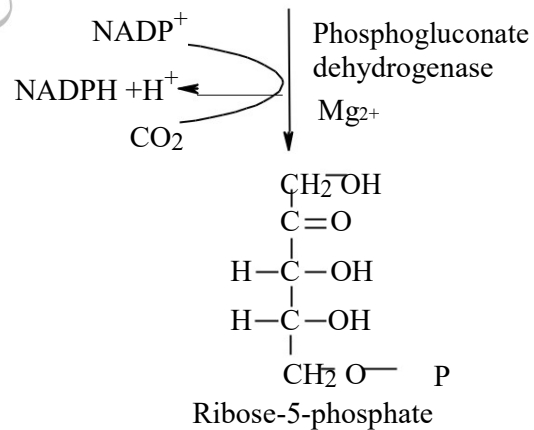
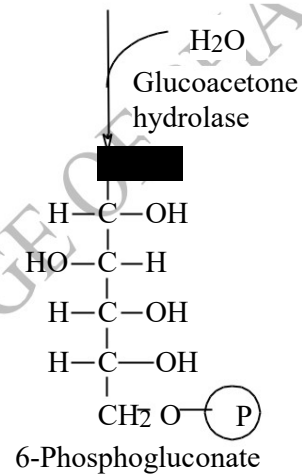
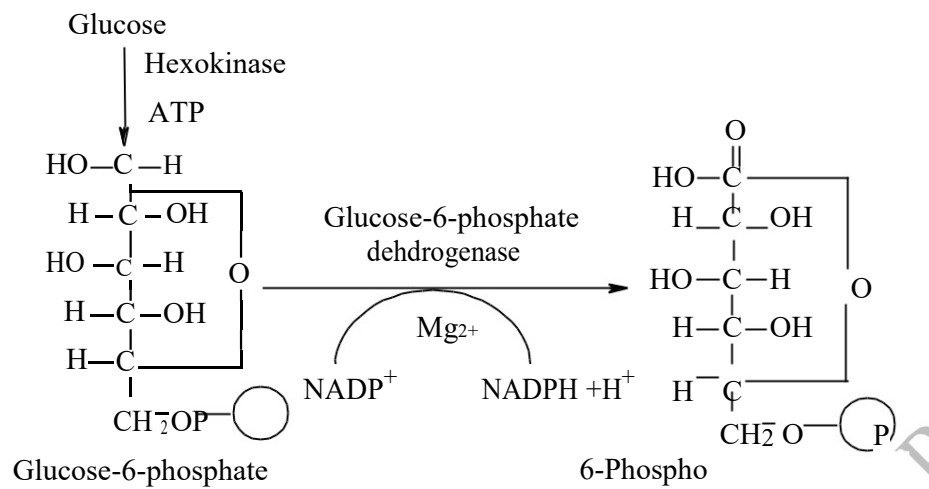
**a) HMP Shunt Pathway**

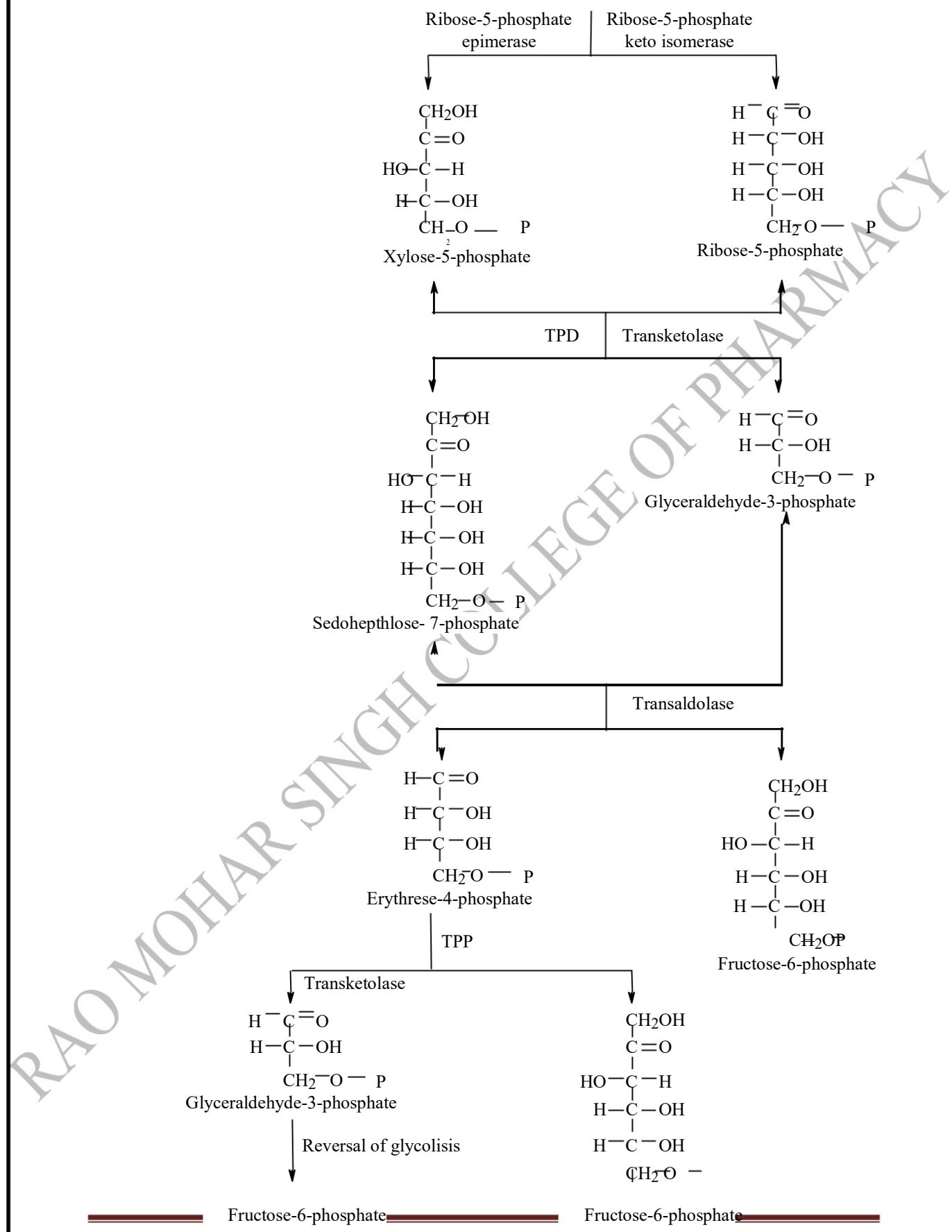
**HEXOSE MONOPHOSPHATE SHUNT (HMP SHUNT):**

The main pathway for the oxidation of glucose is by glycolysis. An alternate pathway for the metabolism of glucose is by HMP shunt. It is also called pentose phosphate pathway or *Warburg-Dicken's pathway*.

**Importance:**

1. This pathway occurs in certain specialized tissue e.g. liver erythrocytes, testis, ovary, lens and cornea.
2. It is a multi cyclic process.
3.  $\text{CO}_2$  is produced in this pathway which is never produced in EM pathway.
4. It is more efficient since more than 30 molecules of ATP are produced for each molecules of glucose oxidized.
5. It is an important pathway for the synthesis and metabolism of pentoses.
6. It gives rise to the formation of pentoses through nucleotide and nucleic acid biosynthesis.







#### Reactions:

- 1. Glucose-6-phosphate to 6-Phosphogluconate:**  
Glucose-6-phosphate is converted to 6-phosphogluconate with help of enzyme. Glucose-6-phosphate dehydrogenase, the latter is hydrolyzed to 6-phosphogluconate by the glucoacetone hydrolase.
- 2. 6-phosphogluconate to Ribulose-5-phosphate:**  
It occurs in presence of the enzyme 6-phosphogluconate dehydrogenase and co-enzyme.
- 3. Ribulose-5-phosphate to Ribose-5-phosphate:**  
It is catalyzed by the enzyme phosphoribose isomerase.
- 4. Ribulose-5-phosphate to Xylose-5-phosphate:**  
Also ribulose-5-phosphate is converted to xylose-5-phosphate. It is catalyzed by the enzyme.
- 5. Xylose-5-phosphate to Glyceraldehyde-3-phosphate:**  
It is catalyzed by the enzyme Trans ketolase during this reaction, a ketol group (active glyceraldehyde) removed from xylose-5-phosphate.
- 6. Ketol to Sedoheptulose:**  
Ketol (formed in the above reaction) combines with ribose-5-phosphate to form sedoheptulose. It is catalyzed by transketolase.
- 7. Sedoheptulose to fructose-6-phosphate:**  
Sedoheptulose is a 7-carbon moiety. A 3 carbon dihydroxy acetone moiety of sedoheptulose is transferred to glyceraldehyde-3-phosphate. As a result fructose-6-phosphate is formed leaving behind erythrose-4-phosphate (A 4-carbon moiety). This reaction is catalyzed by transketolase.
- 8. Erythrose-4-phosphate to Fructose-6-phosphate:**  
Erythrose-4-phosphate combines with ketol to form fructose-6-phosphate. It is catalyzed by transketolase.
- 9. Fructose-6-phosphate to Glucose-6-phosphate:**  
Fructose-6-phosphate can be readily converted to glucose-6-phosphate.  
The net or overall reaction is represented as:  
$$6 \text{ Glucose-6-phosphate} + 12\text{NADP} + 6\text{H}_2\text{O}$$

#### b) Citric Acid Cycle

##### CITRIC ACID CYCLE: TCA cycle (Tri carboxylic acid) or Krebs's cycle

The citric acid cycle (Krebs's cycle or TCA cycle) is the most important metabolic pathway for the energy supply to the body.

About 65 to 70% of ATP is synthesized in Krebs's cycle. Citric acid cycle essentially involves the oxidation of acetyl-CoA to  $\text{CO}_2$  and  $\text{H}_2\text{O}$ . This cycle utilizes about two thirds of total oxygen consumed by the body.

The name TCA cycle is used, since at the outset of the cycle in carboxylic acid citrate (isocitrate and aconitate) participate.

In the anaerobic pathway of glycolysis, glucose is oxidized to pyruvate. Later pyruvate is metabolized to acetyl-CoA. It is an anaerobic pathway. The reactions of citric acid cycle occur in mitochondria.

##### The reactions of citric acid cycle are as follows:

- 1. Acetyl-CoA to Citrate:**  
Acetyl-CoA combines with oxaloacetate to form citrate with the help of enzyme citrate synthetase.
- 2. Citrate to Isocitrate:**  
The two steps of this reaction are:  
(i) Citrate is dehydrated to aconitate  
(ii) Aconitate is rehydrated to form isocitrate with the help of enzyme isocitrate dehydrogenase.
- 3. Isocitrate to  $\alpha$ -ketoglutarate:**  
Oxalosuccinate is decarboxylated to form succinyl-CoA. It is catalyzed by isocitrate dehydrogenase complex.
- 4. Oxalosuccinate to  $\alpha$ -ketoglutarate:**  
Oxalosuccinate is decarboxylated to form  $\alpha$ -ketoglutarate with help of isocitrate dehydrogenase.
- 5.  $\alpha$ -ketoglutarate to Succinyl-CoA:**  
Oxidative decarboxylation of  $\alpha$ -ketoglutarate forms succinyl-CoA with help of enzyme  $\alpha$ -ketoglutarate dehydrogenase complex. It requires the co-enzymes TPO, Lipoate,  $\text{NAD}^+$ ,  $\text{FAD}^+$  and -CoA.

**6. Succinyl-CoA to Succinate:**

Succinyl-CoA is succinate with the help of enzyme succinate thiokinase. This reaction requires GDP which is converted to GTP.

**7. Succinate to Fumarate:**

Dehydrogenation of succinate produces fumarate. It is catalyzed by the enzyme succinate dehydrogenase.

**8. Fumarate to Malate:**

Fumarate is converted to malate with the help of enzyme fumarase.

**9. Malate to Oxaloacetate:**

The molecules with citric acid cycle is started is oxaloacetate. It is regenerated in the step in which malate is converted to oxalo acetate with the help of enzyme malate dehydrogenase. This oxalo acetate combines with the acetyl-CoA and cycle is repeated.

**Energetics of Citric acid cycle:**

The following is number of molecules of ATP synthesized id citric acid cycle.

Acetyl-CoA → Citrate:	03
Isocitrate → α-ketocitrate:	03
α-ketoglurate → Succinyl-CoA:	03
Succinyl-CoA → Succinate:	01
Succinate → Fumarate:	02
Malate → Oxaloacetate:	03
	<hr/> 15

In glycolysis, one molecule of glucose gives two molecules of pyruvate. These two molecules of pyruvate are converted to acetyl-CoA. These enter into citric acid cycle.

So the total numbers of ATP formed in citric acid cycle are  $2 \times 15 = 30$ .

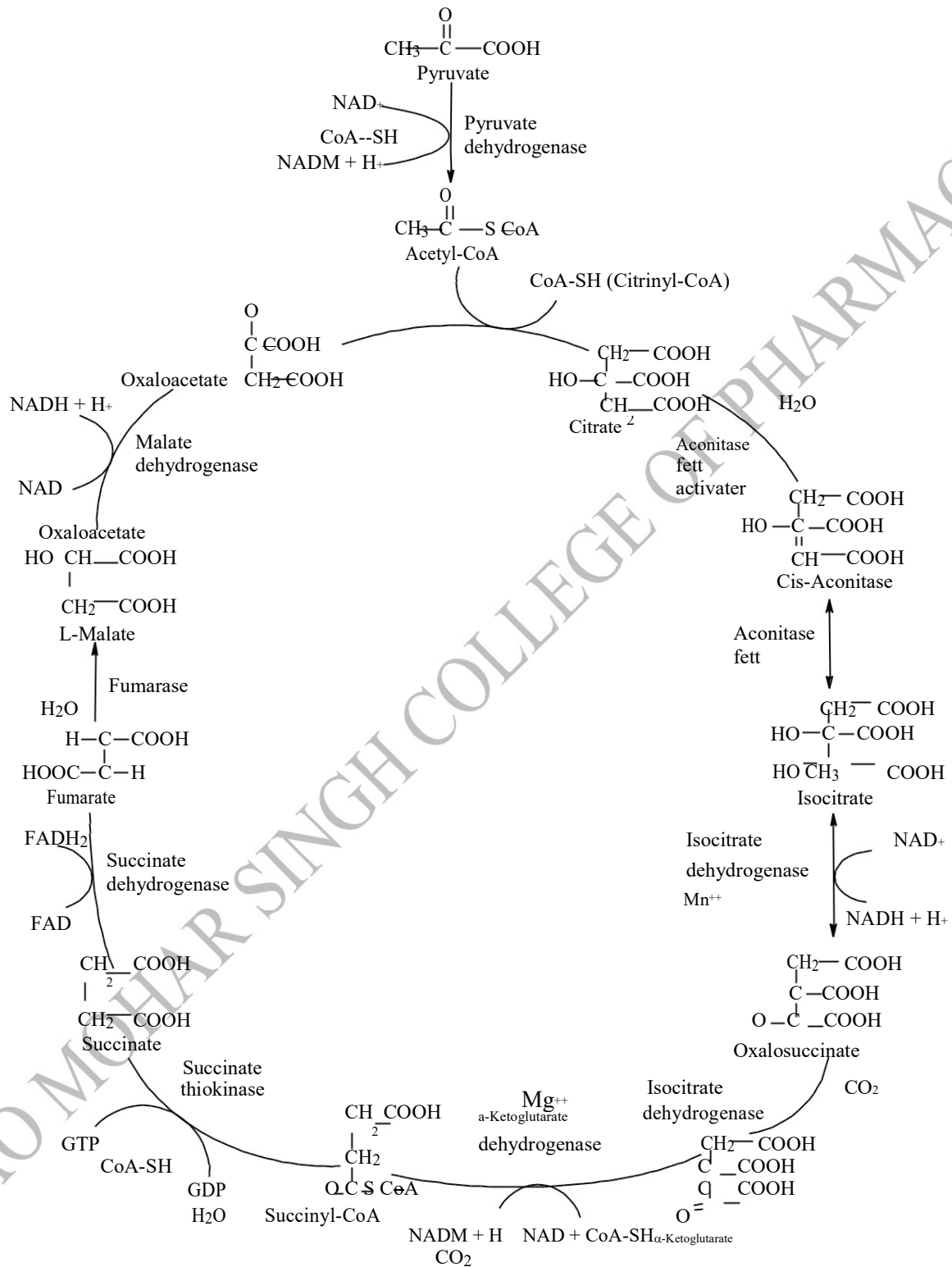
Total number of ATP formed from aerobic oxidation of glucose is 38. It's calculated as follows.

ATP formed from glycolysis: 08  
ATP formed from TCA cycle: 30

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38

**TCA cycle (Tri carboxylic acid) or Kreb's cycle**



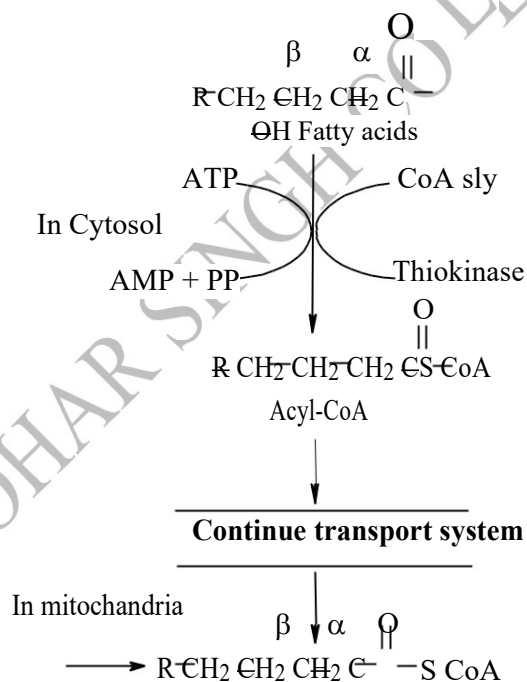
**Significance of Citric acid cycle:**

- c)  $\beta$ - oxidation of fatty acid

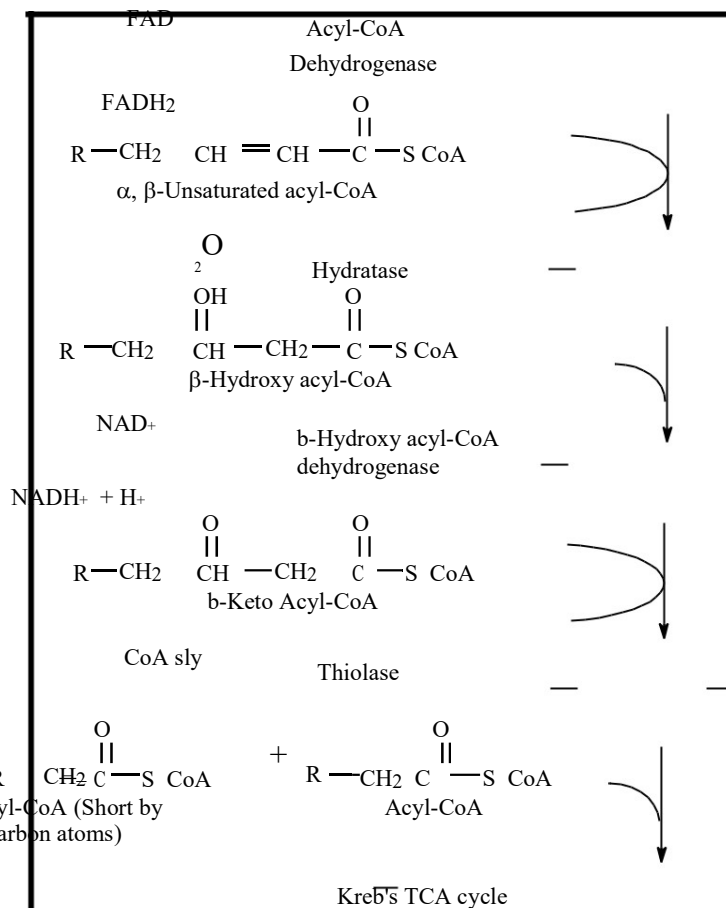
$\beta$ -Oxidation may be defined as the oxidation of fatty acids on the  $\beta$ -carbon atom, this results in the removal of a two carbon fragments of acetyl Co-A and acyl Co-A.

1. Glucogenesis are dependent of  $\beta$ - Oxidation any impairment of this cases hypoglycemia.
2. Acetyl Co-A which is formed in  $\beta$ - Oxidation, is catalyzed for energy production in TCA cycle, biosynthesis of glucose, cholesterol, ketogenic amino acids and nucleic acids.

### **β- Oxidation of fatty a**



## Acyl-CoA

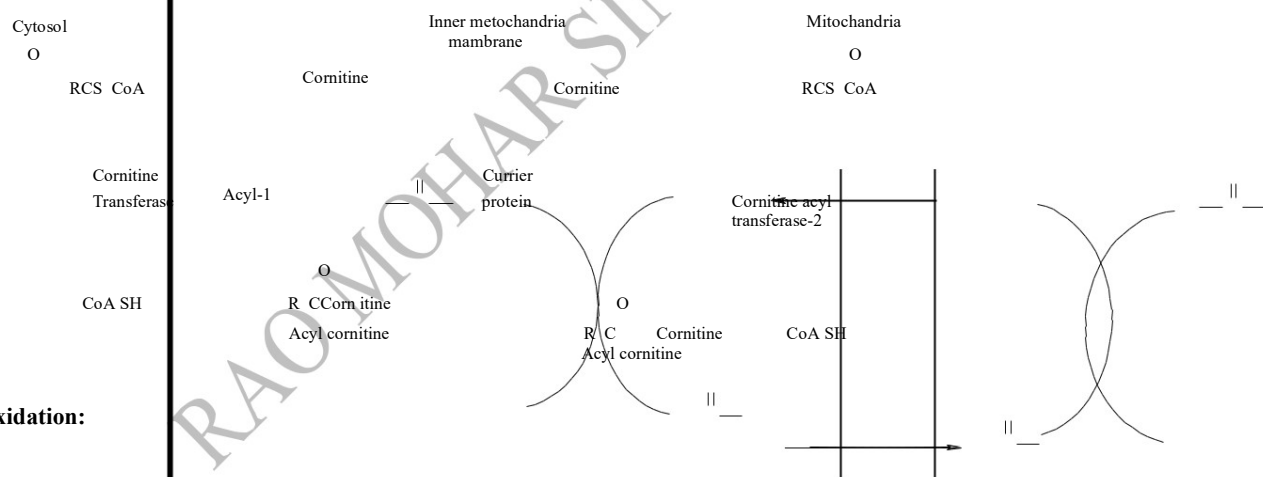


### 1. Activation of fatty acid:

Long chain fatty acids activated to fatty acyl Co-a by the enzyme thiokinase where ATP splits to AMP and PP (Pyrophosphate) in prescience of enzyme A and Mg<sup>+2</sup>

### 2. Transport of acyl-Co-A in to mitochondria (Carnitine transport system):

The inner mitochondria membrane is impermeable to fatty acids. A specialized carrier system operates to transport activated fatty acid from cytosol to the mitochondria. This occurs in four steps:



### 3. β- Oxidation:

## Energetics of $\beta$ - Oxidation (Palmitic acid):

### Mechanism:

#### 1. $\beta$ - Oxidation (7 cycles)

2 FAH<sub>2</sub> [oxidized by ETC, each FAH<sub>2</sub> H gives 2ATP]: 14

7 NADH [oxidized by ETC, each NAH gives 3ATP]:21

#### 2. Form 8 Acetyl-CoA

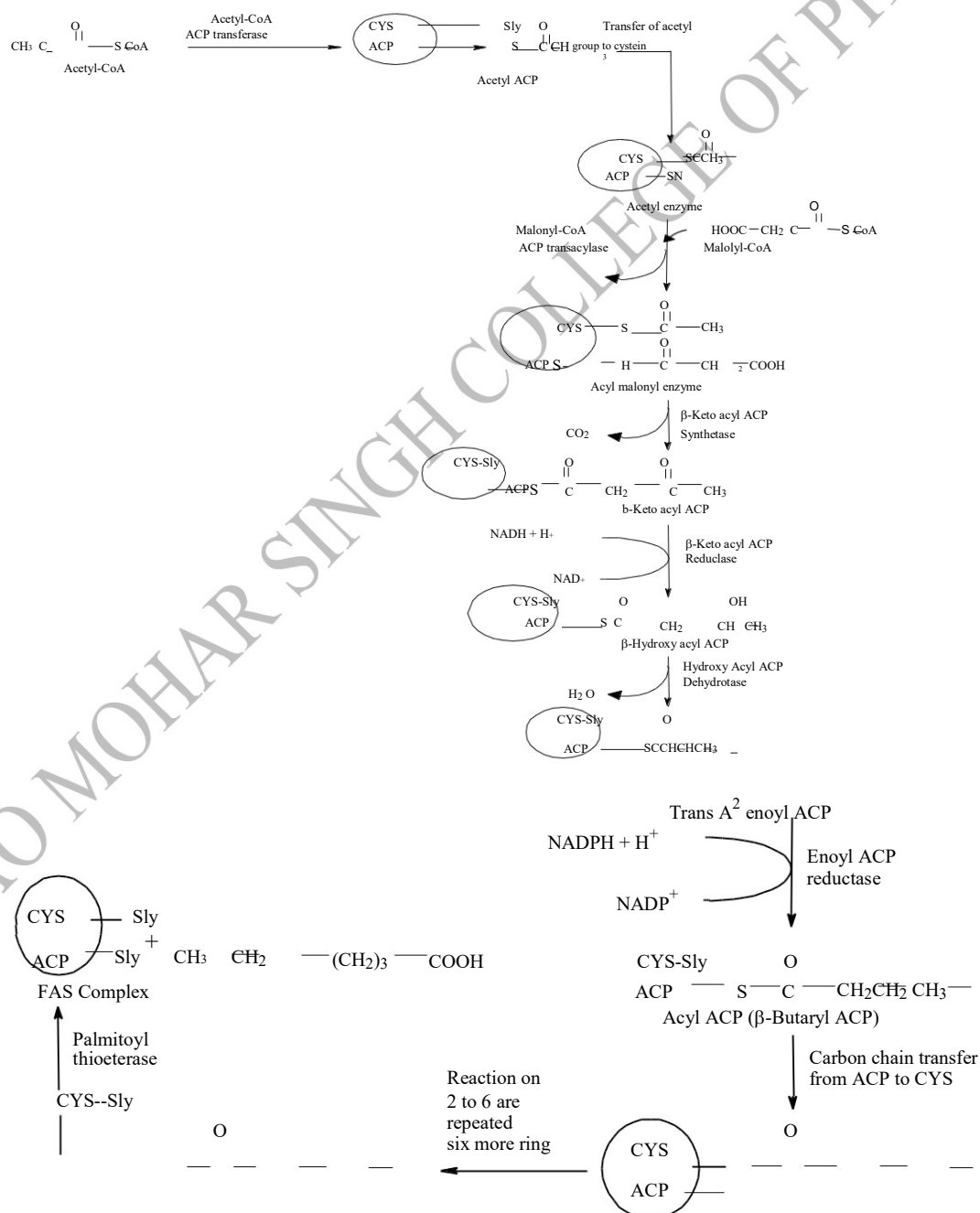
Oxidized by citric acid cycle, each 8 x12 = 96

Total energy from one mole of palmityl-CoA = 131

Energy utilized for formation of palmityl-CoA = 02

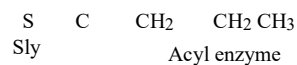
Net yield of oxidation of one mole of Palmitate = 129

## DE-NOVO BIOSYNTHESIS OF FATTY ACIDS





Palmitoyl



The bio synthesis of fatty acid takes place in two phases.

**1. Malonyl CoA formation.**

Acetyl-CoA reacts with CO<sub>2</sub> in the presence of ATP to form malonyl-CoA with the help of an enzyme acetyl-CoA carboxylase.

**2. Fatty acid synthatase complex reactions.**

The multi enzyme complex known as fatty acid synthatase (FAS) take place in the fatty acid synthesis FAS complex consist of two similar subunits (Dimer). Each monomer subunit consists an acyl carrier protein (ACP) attached with its 4-phosphontheine group.

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**The following set of reactions each step in the formation of 16 carbon palmityl-CoA in cytosol.**

1. An enzyme acetyl-CoA ACP transacylase catalyses transfer of two carbon containing acetyl-CoA to ACP of fatty acid synthetase complex. The acetyl moiety is further transferred from ACP to the cysteine residue of the enzyme. This makes the ACP site of the enzyme vacant.
2. The molecule of malonate from malonyl-CoA is transformed to ACP of FAS complex catalyzed by the enzyme malonyl CoA ACP transacylase.
3. The enzyme  $\beta$ -keto acyl ACP synthetase catalyzes their reaction in which acetyl group attached to cysteine of FAS complex is transferred to the malonyl unit already attached to ACP of the FAS complex with removal of  $\text{CO}_2$  to form  $\beta$ -keto acyl ACP.
4. The  $\beta$ -keto acyl ACP reductase reduces  $\beta$ -keto acyl ACP in to  $\beta$ -hydroxy acyl ACP with the help of reducing equivalent supplied by NADPH.
5. The  $\beta$ -hydroxy keto acyl ACP dehydrogenase. Brings the dehydration of  $\beta$ -hydroxy keto acyl ACP with the elimination of  $\text{H}_2\text{O}$  molecule and introduction of the double bond (Between 2 and 3 atoms) into molecule to form trans  $^2$  Enoyl ACP.
6. An enzyme Enoyl ACP reductase brings about the NADPH dependent reduction. This produces acyl ACP (Butyryl group). The carbon chain so formed is now transferred to cysteine residue of FAS complex.

The 6 more cycles of reaction from 2-6 take place respectively. Each cycle (2-6) increases the chain length of the growing fatty acid by 2 carbon atoms.

Q.35 Discuss the normal and abnormal constituents of urine, how are they detected in urine.