BIO504 – BIOCHEMISTRY I

MID TERM IMPORTANT QUESTIONS

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Admin: **BS Biological Sciences** (One place to all your solutions)

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1. What is complex lipids? Name its types.

Complex lipids are lipids that, in addition to fatty acids and alcohol, contain other chemical groups such as phosphoric acid, nitrogenous bases, carbohydrates, or sulfur. These extra groups give them specific structural and functional roles, especially in cell membranes.

Types of Complex Lipids

1. ***Phospholipids***

They contain phosphoric acid. Examples are Lecithin, Cephalin, and Sphingomyelin

2. ***Glycolipids***

They contain carbohydrate groups. Examples are Cerebrosides, Gangliosides.

3. ***Lipoproteins***

These lipids combined with proteins. Example are HDL, LDL.

2. What steps are involved in protein folding?

Steps involved in protein folding:

1. ***Primary structure formation*** – Linear sequence of amino acids linked by peptide bonds.
2. ***Secondary structure formation*** – Local folding into α-helices and β-pleated sheets stabilized by hydrogen bonds.
3. ***Tertiary structure formation*** – Further folding of the polypeptide chain into a three-dimensional shape due to side-chain interactions (hydrophobic interactions, ionic bonds, hydrogen bonds, and disulfide bridges).
4. ***Quaternary structure formation*** – Association of two or more polypeptide chains to form a functional protein.

3. Define Selenocysteine and its function.

Selenocysteine is a rare, genetically encoded amino acid in which selenium replaces sulfur of cysteine. It is known as the 21st amino acid and is incorporated into proteins during translation via a specific UGA codon and a special tRNA.

Function:

- Plays a key role in redox reactions
- Acts as an essential component of selenoproteins, such as glutathione peroxidase and thioredoxin reductase
- Protects cells from oxidative damage by reducing peroxides

4. Write properties of side chain in glutamate and asparagine.

Properties of side chains:

Glutamate (Glu)

- Side chain contains a carboxyl ($–COO^-$) group
- Negatively charged at physiological pH
- Acidic amino acid
- Hydrophilic and water-soluble
- Participates in ionic (salt bridge) interactions and hydrogen bonding

Asparagine (Asn)

- Side chain contains an amide ($–CONH_2$) group
- Uncharged (neutral) at physiological pH
- Polar and hydrophilic
- Forms hydrogen bonds
- Important in protein stability and recognition

5. Explain cis isomer in saturated fatty acid.

Cis isomer in fatty acids refers to the arrangement of hydrogen atoms around a carbon–carbon double bond, where the hydrogens are on the same side of the double bond. This causes a bend or kink in the fatty acid chain. In saturated fatty acids, cis isomerism does not occur because they do not contain any carbon–carbon double bonds. All carbon atoms are fully saturated with hydrogen, so no geometric (cis–trans) isomerism is possible. Cis isomerism is therefore a feature of unsaturated fatty acids, not saturated ones.

6. Write functions of carbohydrates.

Functions of carbohydrates

- Serve as the primary source of energy, with glucose acting as the main fuel for cellular metabolism
- Provide energy storage, stored as glycogen in animals and starch in plants
- Act as structural components, such as cellulose in plant cell walls and chitin in fungi and arthropods
- Participate in cell recognition and cell–cell communication as components of glycoproteins and glycolipids on cell surfaces
- Supply carbon skeletons for the synthesis of amino acids, fatty acids, and nucleotides

- Play a role in lubrication and protection of tissues through mucopolysaccharides (glycosaminoglycans)
- Involved in detoxification processes, especially in the liver (glucuronic acid conjugation)

7. Write conformation properties of beta in protein structure.

Conformational properties of β-structure (β-pleated sheet) in protein structure

- Formed by extended polypeptide chains aligned side by side
- Stabilized by hydrogen bonds between the carbonyl (C=O) group of one peptide bond and the amide (N–H) group of an adjacent chain
- May be arranged as parallel β-sheets (chains run in the same direction) or antiparallel β-sheets (chains run in opposite directions)
- Hydrogen bonds are more linear and stronger in antiparallel sheets than in parallel sheets
- The structure appears pleated or zig-zag due to tetrahedral geometry of carbon atoms
- Side chains (R groups) extend alternately above and below the plane of the sheet
- Provide high tensile strength and rigidity to proteins
- Commonly found in fibrous proteins such as silk fibroin and in the core of many globular proteins

8. Describe: Immunoglobulin, transport protein and storage protein.

Immunoglobulins are glycoproteins produced by B-lymphocytes in response to antigens. They play a key role in the immune system by recognizing and binding specific antigens. Examples include IgG, IgA, and IgM.

Transport proteins are proteins that carry molecules or ions across cell membranes or in body fluids. They help in the movement of essential substances and maintaining homeostasis. Examples include hemoglobin, transferrin, and albumin.

Storage proteins are proteins that store nutrients or essential ions for later use by the organism. They provide reserves of amino acids or metal ions for metabolic needs. Examples include ferritin, casein, and ovalbumin.

9. Explain pka.

pKa is the acid dissociation constant, which measures the strength of an acid in solution. It indicates how easily an acid donates a proton. A low pKa value corresponds to a strong acid that dissociates easily, while a high pKa value corresponds to a weak acid that dissociates less. In biochemistry, pKa is important for understanding the ionization of amino acids, nucleotides, and other biomolecules, which influences protein structure, enzyme activity, and solubility. It also helps predict the protonation state of a molecule at a given pH.

10. Define digestive protein with suitable examples.

Digestive proteins are enzymes that break down food macromolecules into smaller absorbable units during digestion. They help convert proteins, carbohydrates, and fats into amino acids, sugars, and fatty acids, respectively. Examples include pepsin, which breaks down proteins in the stomach; trypsin, which digests proteins in the small intestine; and amylase, which breaks down starch into sugars.

11. Define renaturation with the process of ribonuclease A.

Renaturation is the process by which a **den**atured protein regains its original three-dimensional structure and biological activity after the removal of denaturing conditions. In the case of ribonuclease A**,** the process involves:

- The protein is first denatured using agents like urea or guanidine hydrochloride, which unfold the protein and break its disulfide bonds.
- The disulfide bonds are then reduced, leaving the protein in a completely unfolded state.
- Upon removal of the denaturing agent and allowing an oxidizing environment, the protein spontaneously refolds into its native conformation.
- Ribonuclease A is able to regain its enzymatic activity, demonstrating that the amino acid sequence alone contains the information for correct folding**.**

12. Explain composition of proteins.

Composition of proteins refers to the chemical makeup and structural components that constitute proteins. Proteins are polymers of amino acids, which are linked together by peptide bonds forming a polypeptide chain.

- ***Amino acids:*** The basic building blocks of proteins, each containing an amino group ($–NH_2$)**,** a carboxyl group (–COOH)**,** a hydrogen atom, and a unique side chain (R group) attached to a central carbon. The sequence and type of amino acids determine the protein's properties and function.
- ***Peptide bonds:*** Covalent bonds formed between the amino group of one amino acid and the carboxyl group of another through a condensation reaction, creating the protein backbone.
- ***Other elements:*** Proteins may also contain sulfur (in cysteine and methionine), phosphorus (in phosphorylated proteins), or metal ions (in metalloproteins) depending on their function.
- ***Side chains (R groups):*** Impart chemical diversity, influencing polarity, charge, and hydrophobicity**,** which affect the protein's folding, stability, and activity**.**

13. What is atomic number and atomic mass of oxygen?

Atomic number of oxygen: 8 (indicates it has 8 protons in its nucleus)

Atomic mass of oxygen: approximately 16 u (unified atomic mass units), which represents the average mass of its isotopes.

14. What is crystalline glucose?

Crystalline glucose is the solid, pure form of glucose obtained when glucose molecules arrange themselves in a regular, repeating lattice structure. In this form, glucose appears as white, odorless, sweet-tasting crystal**s**. It is highly soluble in water and is commonly used in food, medical, and laboratory application**s** as a source of energy or as a standard for biochemical experiments.

15. Define cooperative binding of oxygen.

Cooperative binding of oxygen refers to the phenomenon in which the binding of one oxygen molecule to a protein (like hemoglobin) increases the affinity of the remaining binding sites for oxygen.

- In hemoglobin, which has four subunits, the binding of the first oxygen induces a conformational change in the protein, making it easier for the second, third, and fourth oxygen molecules to bind.
- This property allows hemoglobin to efficiently pick up oxygen in the lungs (high oxygen concentration) and release it in tissues (low oxygen concentration).

16. Define transport protein and contractile protein.

Transport proteins are proteins that carry or move molecules and ions across cell membranes or through the bloodstream. Examples include hemoglobin, which transports oxygen, and albumin, which carries fatty acids.

Contractile proteins are proteins involved in muscle contraction and movement. They generate force by interacting with each other in muscle fibers. Examples include actin and myosin.

17. Write a note on monosaccharides.

Monosaccharides are the simplest form of carbohydrates, consisting of a single sugar unit that cannot be hydrolyzed into simpler sugars. They serve as the building blocks for more complex carbohydrates like disaccharides and polysaccharides.

- ***Structure:*** Monosaccharides contain carbon, hydrogen, and oxygen in a general formula of $(CH_2O)n$, where n is usually 3–7. They have a carbonyl group (aldehyde or ketone) and multiple hydroxyl groups.
- ***Classification:*** Based on the carbonyl group, they are classified as aldoses (aldehyde group, e.g., glucose) or ketoses (ketone group, e.g., fructose). They can also be classified by the number of carbon atoms, such as triose, tetrose, pentose, or hexose.
- ***Properties:*** They are water-soluble, sweet-tasting, and can exist in linear or cyclic forms in solution.
- ***Functions:*** Provide immediate energy, serve as metabolic intermediates, and act as precursors for nucleotides and amino acids.
- ***Examples:*** Glucose, fructose, galactose, ribose, and deoxyribose.

18. Define Quaternary structure of protein.

Quaternary structure of a protein **is the** level of protein structure formed by the assembly of two or more polypeptide chains (subunits) into a single functional protein complex.

- The subunits are held together by non-covalent interactions such as hydrogen bonds, ionic bonds, hydrophobic interactions, and sometimes disulfide bridges.
- This structure determines the functional form of the protein and allows cooperative interactions between subunits.

  Examples: Hemoglobin (four subunits), DNA polymerase, and immunoglobulins.

19. How pyruvate hydrolysis and convert to amino acids?

Pyruvate hydrolysis and conversion to amino acids involves the transformation of pyruvate, a key intermediate of glycolysis, into various amino acids through transamination or other metabolic pathways**.**

- ***Pyruvate hydrolysis*****:** Pyruvate can be decarboxylated or oxidized to produce intermediates such as acetyl-CoA or oxaloacetate, depending on the metabolic pathway. These reactions involve enzymes like pyruvate dehydrogenase.
- ***Conversion to amino acids:*** Pyruvate serves as a precursor for several amino acids:
    - ***Alanine:*** Pyruvate undergoes transamination, where an amino group from glutamate is transferred to pyruvate to form alanine, catalyzed by alanine aminotransferase.
    - ***Other amino acids:*** Through metabolic pathways, pyruvate can also contribute indirectly to valine, leucine, and isoleucine synthesis.

20. Define four levels of protein structure.

Protein structure is organized into four levels based on the complexity of folding and assembly:

- ***Primary structure:*** The linear sequence of amino acids in a polypeptide chain, held together by peptide bonds**.** It determines the protein's identity and properties.
- ***Secondary structure:*** Local folding of the polypeptide chain into structures like α-helices and β-pleated sheets, stabilized by hydrogen bonds between backbone atoms.
- ***Tertiary structure:*** The three-dimensional folding of a single polypeptide chain, stabilized by hydrophobic interactions, hydrogen bonds, ionic bonds, and disulfide bridges among side chains.
- ***Quaternary structure:*** The assembly of two or more polypeptide chains (subunits) into a functional protein complex, held together by non-covalent interactions or disulfide bonds.

21. Differentiate between alpha, beta and gamma carbon.

Differentiation between α, β, and γ carbon:

- ***Alpha (α) carbon:***
    - The first carbon atom attached directly to the functional group of a molecule.
    - In amino acids, the α-carbon is the central carbon bonded to the amino group, carboxyl group, hydrogen, and side chain (R group).
- ***Beta (β) carbon:***
    - The second carbon atom away from the functional group, bonded to the α-carbon.
    - In amino acids, the β-carbon is part of the side chain next to the α-carbon.
- ***Gamma (γ) carbon:***
    - The third carbon atom away from the functional group, bonded to the β-carbon.
    - Found further along the side chain of amino acids or other organic molecules.

22. Write biomedical importance of oligosaccharides.

Biomedical importance of oligosaccharides:

- ***Cell recognition and signaling:*** Oligosaccharides attached to proteins and lipids **(**glycoproteins and glycolipids**)** on cell surfaces play key roles in **c**ell–cell communication, immune recognition, and receptor binding**.**
- ***Immune response:*** They are involved in antigenicity, helping the immune system distinguish self from non-self**,** as seen in blood group antigens.
- ***Drug targeting and delivery:*** Oligosaccharides can be used to target drugs to specific cells or tissues by recognizing cell surface receptors.
- ***Protein stability and folding:*** Glycosylation of proteins via oligosaccharides improves protein stability, solubility, and proper folding**.**
- ***Diagnostics and therapeutics:*** Abnormal oligosaccharide patterns are linked to cancer, congenital disorders of glycosylation, and infectious diseases**,** making them useful in biomarkers and therapeutic research**.**

23. Define domain in protein.

Domain in a protein is a distinct, compact, and stable region of a polypeptide chain that can fold independently and often has a specific function.

- A single protein may contain one or more domains, each contributing to the protein's overall activity.
- Domains can be involved in binding ligands, catalysis, or structural support, and are often conserved across different proteins.

Example: The SH2 domain in signaling proteins binds phosphorylated tyrosine residues, while the catalytic domain of enzymes carries out the chemical reaction.

24. Define Lactose and write its properties.

Lactose is a disaccharide sugar composed of one molecule of glucose and one molecule of galactose linked by a β-1,4-glycosidic bond. It is commonly found in milk and dairy products.

Properties of lactose:

- ***Physical state:*** White, crystalline, and sweet-tasting solid
- ***Solubility:*** Soluble in water, less soluble than sucrose
- ***Reducing sugar:*** Lactose has a free aldehyde group, so it can act as a reducing sugar in chemical reactions
- ***Hydrolysis:*** Can be hydrolyzed by the enzyme lactase into glucose and galactose
- ***Sweetness:*** Less sweet than sucrose
- ***Stability:*** Stable under normal conditions but may caramelize or decompose on heating at high temperatures

25. Explain importance of carbon attached with heme group in liver.

The carbon in the heme group is part of the porphyrin ring that holds the iron atom in place.

- In the **liver**, heme is found in enzymes like **cytochrome P450**.
- These enzymes help **break down drugs, toxins, and other chemicals** so they can be removed from the body.
- The carbon framework keeps the iron stable and allows the enzyme to **work properly**.

26. Differentiate between Glucaric Acid, Glucuronic Acid and Gluconic Acid.

Glucaric acid is a dicarboxylic acid formed by the oxidation of both the aldehyde group (C1) and the primary alcohol group (C6) of glucose. It contains two carboxylic acid groups and is used in applications such as detergents and corrosion inhibitors.

Glucuronic acid is a uronic acid formed by the oxidation of the C6 (primary alcohol) of glucose. It has one carboxylic acid group at C6 and is important in the liver for detoxification, where it forms glucuronides to help remove toxins from the body.

Gluconic acid is an aldonic acid produced by the oxidation of the C1 (aldehyde) of glucose. It contains one carboxylic acid group at C1 and is commonly used in food additives, pharmaceuticals, and cleaning agents.

27. Explain Disulphide Bridge.

Disulfide Bridge is a covalent bond formed between the sulfur atoms of two cysteine amino acids in a protein.

- It is also called a disulfide bond or S–S bond.
- Disulfide bridges help stabilize the three-dimensional structure of proteins by linking different parts of the polypeptide chain or different chains together.
- They are important for maintaining the tertiary and quaternary structures of proteins.
- ***Example:*** Insulin contains disulfide bridges that hold its two chains together, and lysozyme has several disulfide bonds that stabilize its structure.

28. Differentiate between Tyrosine and Tryptophan.

Differences between Tyrosine and Tryptophan:

- ***Chemical structure:*** Tyrosine has a phenol group attached to its side chain, while tryptophan contains an indole ring in its side chain.
- ***Polarity:*** Both are polar, but tyrosine is slightly more polar due to the hydroxyl group, whereas tryptophan is less polar and more hydrophobic because of its larger aromatic ring.
- ***Aromaticity:*** Both are aromatic amino acids, but tryptophan's indole ring is larger and contains nitrogen**,** while tyrosine has a simpler benzene ring with –OH.
- ***Function:*** Tyrosine is a precursor for catecholamines (dopamine, epinephrine, norepinephrine) and thyroid hormones, while tryptophan is a precursor for serotonin, melatonin, and niacin (vitamin B3)**.**
- ***UV absorption:*** Tyrosine absorbs UV light at ~275 nm, whereas tryptophan absorbs strongly at ~280 nm**.**

29. Categorize isomers in types.

Isomers are molecules with the same molecular formula but different arrangements of atoms.

1. Structural isomers: Atoms are connected differently. Examples:

- ***Chain isomers:*** Different carbon chain (butane and isobutane)
- ***Position isomers:*** Functional group in different position (1-propanol and 2-propanol)
- ***Functional group isomers:*** Different functional group (ethanol and dimethyl ether)

2. Stereoisomers: Atoms connected the same way but arranged differently in space. Examples:

- ***Geometric (cis–trans) isomers:*** Different around double bond (cis-butene and trans-butene)
- ***Optical isomers (enantiomers):*** Mirror images that cannot be superimposed (L- and D-alanine)

30. Write properties of aliphatic non polar R group.

Properties of aliphatic nonpolar R groups in amino acids:

- Contain hydrocarbon chains (alkyl groups) such as $–CH_3$, $–CH_2–CH_3$, etc.
- Hydrophobic in nature and insoluble in water
- Do not form hydrogen bonds or ionic interactions with water
- Often found in the interior of proteins, helping to stabilize protein structure through hydrophobic interactions
- Examples of amino acids with aliphatic nonpolar R groups: Glycine, Alanine, Valine, Leucine, Isoleucine, Methionine

31. Enlist three positively charged amino acids.

Three positively charged amino acids are:

- **Lysine (Lys, K)**
- **Arginine (Arg, R)**
- **Histidine (His, H)**

32. What are geometric isomers? Explain.

Geometric isomers are a type of stereoisomer in which molecules have the same molecular formula and connectivity but differ in the spatial arrangement of atoms around a double bond or ring**.**

- In double bonds, the rotation is restricted, so substituents can be arranged differently.
- Types:
    - ***Cis isomer:*** Similar groups are on the same side of the double bond or ring.
    - ***Trans isomer:*** Similar groups are on opposite sides**.**
- Geometric isomers often have different physical and chemical properties, such as melting point, boiling point, and biological activity.

Example: In 2-butene, cis-2-butene has both methyl groups on the same side, while trans-2-butene has them on opposite sides.

33. Explain 2,3 biphosphoglycerate in detail.

2,3-Bisphosphoglycerate (2,3-BPG) is a small molecule found in red blood cells that helps release oxygen from hemoglobin to the tissues**.**

- It binds to deoxygenated hemoglobin and stabilizes its low-oxygen form, making it easier for hemoglobin to let go of oxygen.
- The amount of 2,3-BPG increases in low-oxygen conditions, like at high altitude or in anemia, helping the body deliver more oxygen to tissues.
- In fetal hemoglobin, 2,3-BPG binds less, so fetal hemoglobin can hold oxygen more tightly than adult hemoglobin.

34. What is meant by amyloidosis?

Amyloidosis is a condition in which abnormal protein deposits, called amyloids, accumulate in tissues and organs, disrupting their normal function.

- Amyloids are insoluble, fibrous protein aggregates formed from misfolded proteins.
- The deposits can occur in various organs such as the heart, kidneys, liver, and nervous system**.**
- Types include primary amyloidosis (caused by abnormal immunoglobulin light chains) and secondary amyloidosis (associated with chronic inflammation or infection).
- Symptoms depend on the organs affected, including kidney failure, heart problems, or nerve damage**.**

35. What is the derivation of hydrophobic proteins?

Hydrophobic proteins are proteins that have a large proportion of nonpolar, water-repelling amino acids in their structure.

- The derivation of hydrophobic proteins refers to their composition being rich in nonpolar aliphatic and aromatic amino acids such as valine, leucine, isoleucine, phenylalanine, and methionine**.**
- These amino acids have nonpolar side chains that avoid water and tend to cluster in the interior of the protein, helping to stabilize the three-dimensional structure through hydrophobic interactions.
- Hydrophobic proteins are often found in membrane proteins or protein cores, where they maintain structural integrity and contribute to protein folding and function**.**

36. Explain the titration curve of glycine.

Titration curve of glycine shows how the pH of a glycine solution changes as a strong acid or base is gradually added. Glycine is an amino acid with two ionizable groups:

- Amino group ($–NH_3^+$) with pKa ≈ 9.6
- Carboxyl group (–COOH) with pKa ≈ 2.3

Key points of the curve:

- At low pH, glycine exists mostly as fully protonated ($–NH_3^+$ and –COOH)**.**
- As base is added, the carboxyl group loses a proton first, forming the zwitterion ($–NH_3^+$ and $–COO^-$). This occurs near pH 2.3, showing the first buffering region.
- The isoelectric point (pI) is the pH where glycine has no net charge, around pH 6.0. At this point, it exists mainly as a zwitterion.
- Further addition of base deprotonates the amino group ($–NH_3^+ \rightarrow –NH_2$) around pH 9.6, giving the second buffering region.

37. Write two examples of disaccharides.

Two examples of disaccharides are:

- ***Sucrose*** – composed of glucose and fructose
- ***Lactose*** – composed of glucose and galactose

38. Write properties of fatty acids.

Properties of fatty acids:

- ***Chemical composition:*** Composed of a hydrocarbon chain and a carboxyl group (–COOH) at one end
- ***Solubility:*** Insoluble in water if long-chain; soluble in organic solvents
- ***Acidity:*** Weak acids due to the carboxyl group; can form salts (soaps) with bases
- ***Melting point:*** Saturated fatty acids have higher melting points than unsaturated fatty acids of the same chain length
- ***Physical state:*** Short-chain fatty acids are usually liquid, while long-chain saturated fatty acids are solid at room temperature
- ***Reactivity:*** Can undergo oxidation, hydrogenation, and esterification reactions
- ***Biological role:*** Serve as energy storage, membrane components, and precursors for signaling molecules

39. Write properties of serine and theorine.

Properties of Serine:

- Contains a polar hydroxyl (–OH) group in its side chain
- Hydrophilic and can form hydrogen bonds
- Uncharged at physiological pH
- Involved in enzyme active sites and phosphorylation
- Examples of proteins containing serine: enzymes like trypsin and structural proteins

Properties of Threonine:

- Contains a polar hydroxyl (–OH) group and an extra methyl group in its side chain
- Hydrophilic and capable of forming hydrogen bonds
- Uncharged at physiological pH
- Can be phosphorylated, important in signal transduction
- Found in proteins like collagen and various enzymes

40. What is tautomerization?

Tautomerization is a chemical process in which a molecule reversibly shifts a hydrogen atom and a double bond**,** resulting in two isomeric forms called tautomers.

- The most common type is keto–enol tautomerism, where a keto form (C=O) converts to an enol form (C=C–OH)**.**
- Tautomerization is important in biochemistry, especially in nucleic acids, where it can affect base pairing and DNA stability**.**
- It is usually a rapid, equilibrium process under physiological conditions.

41. Explain beta bands.

Beta (β) bands refer to a type of secondary structure in proteins, specifically the β-pleated sheet.

- Formed when extended polypeptide chains lie side by side and are connected by hydrogen bonds between the carbonyl (C=O) of one chain and the amide (N–H) of another.
- Can be arranged as parallel β-sheets (chains run in the same direction) or antiparallel β-sheets (chains run in opposite directions).
- The structure has a pleated or zig-zag appearance due to the tetrahedral geometry of the α-carbon.
- Side chains project alternately above and below the plane of the sheet.
- Provides stability and rigidity to the protein structure.
- ***Example:*** Found in fibrous proteins like silk fibroin and in the core of many globular proteins.

42. Write a note on proteins involved in respiration process.

Proteins involved in the respiration process are mainly enzymes and electron carriers that help in cellular energy production through glycolysis, the Krebs cycle, and oxidative phosphorylation.

- ***Cytochromes:*** Heme-containing proteins in the electron transport chain (ETC) that transfer electrons and help generate a proton gradient for ATP synthesis.
- ***ATP synthase:*** A large protein complex in the mitochondrial inner membrane that uses the proton gradient to synthesize ATP from ADP and inorganic phosphate.
- ***NADH dehydrogenase (Complex I), Succinate dehydrogenase (Complex II), and Cytochrome c oxidase (Complex IV):*** Enzymes in the ETC that facilitate electron transfer and pump protons to maintain the electrochemical gradient.
- ***Other carrier proteins:*** Such as ubiquinone (coenzyme Q) and cytochrome c, which shuttle electrons between complexes.

43. What are the effects of abnormal sequence of amino acids on protein folding?

Effects of abnormal sequence of amino acids on protein:

- ***Altered folding:*** Changes in the amino acid sequence can prevent the protein from folding into its correct three-dimensional structure, affecting stability.
- ***Loss of function:*** The protein may lose its biological activity if the active site or binding region is disrupted.
- ***Formation of aggregates:*** Misfolded proteins may clump together, forming insoluble aggregates that can be toxic to cells.
- ***Disease association:*** Abnormal sequences can lead to genetic disorders or diseases, such as:
  - ***Sickle cell anemia*** – substitution of glutamic acid with valine in hemoglobin
  - ***Cystic fibrosis*** – deletion of phenylalanine in CFTR protein
  - ***Amyloidosis or neurodegenerative diseases*** – misfolded proteins forming deposits

44. Write importance of sorbitol.

Importance of Sorbitol:

- ***Sugar substitute:*** Sorbitol is used as a low-calorie sweetener in sugar-free foods, chewing gums, and diabetic products.
- ***Humectant:*** It helps retain moisture in food and cosmetic products.
- ***Laxative effect:*** Sorbitol draws water into the intestines, aiding bowel movement in cases of constipation.
- ***Pharmaceutical uses:*** Used as an excipient in tablets and syrups to improve taste and texture.
- ***Metabolic role:*** In the body, sorbitol is part of the polyol pathway, where glucose is converted to sorbitol and then to fructose, which can be important in energy metabolism.

45. What is starch and its structure?

Starch is a polysaccharide carbohydrate that serves as the primary energy storage molecule in plants. It is composed of glucose units linked together by glycosidic bonds.

Structure of starch:

- Starch is made of two types of glucose polymers:
    - ***Amylose:*** A mostly linear chain of glucose units connected by α-1,4-glycosidic bonds; it forms a helical structure.
    - ***Amylopectin:*** A branched polymer with α-1,4-glycosidic bonds in the linear chains and **α-**1,6-glycosidic bonds at branch points.
- The combination of amylose and amylopectin allows starch to be compact for storage and readily hydrolyzed to glucose when energy is needed.
- Starch appears as granules in plant cells, such as in potatoes, rice, and maize**.**