BIO504 – BIOCHEMISTRY I

FINAL TERM MOST IMPORTANT QUESTIONS

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1. How fireflies produce light?

Fireflies produce light through a process called bioluminescence, which is a chemical reaction that occurs in specialized light-emitting cells called photocytes. Here's how it works:

a. ***Luciferase:*** Fireflies produce an enzyme called luciferase, which catalyzes the oxidation of a molecule called luciferin. Luciferase speeds up the reaction between luciferin and oxygen.

b. ***Luciferin and ATP:*** Luciferin is a light-emitting molecule found in the firefly's abdomen. When luciferase catalyzes the reaction between luciferin and oxygen, it produces an excited molecule called oxyluciferin. This reaction requires energy, which is provided by adenosine triphosphate (ATP), a molecule involved in cellular energy metabolism.

c. ***Light Emission:*** The excited oxyluciferin molecule releases excess energy in the form of light as it returns to its ground state. This light emission gives fireflies their characteristic glow.

d. ***Regeneration:*** After emitting light, the oxyluciferin molecule is regenerated back into luciferin through a series of enzymatic reactions, allowing the firefly to produce light repeatedly.

2. Write a short note on bee wax.

Beeswax is a natural wax produced by honeybees. It forms the structure of honeycombs and is harvested for various uses. Beeswax has a pleasant aroma, a rich golden color, and is used in making candles, cosmetics, and food wraps. It's valued for its natural, non-toxic properties and has been used for centuries in various cultures.

3. Write properties of lipid compounds.

Lipid compounds possess several key properties:

1. Hydrophobicity: Lipids are primarily nonpolar and do not dissolve in water. They are soluble in nonpolar solvents such as chloroform and benzene.

2. Energy Storage: Lipids store a large amount of energy. Gram for gram, they provide more than twice the energy content of carbohydrates and proteins.

3. Insulation and Protection: Lipids act as insulators, helping to maintain body temperature and protect vital organs by providing a cushioning effect.

4. Structural Components: Lipids are crucial components of cell membranes. Phospholipids, for example, form the bilayer structure of cell membranes, contributing to their fluidity and integrity.

5. Chemical Messengers: Some lipids, like steroid hormones, serve as signaling molecules that regulate various physiological processes.

6. Water Repellency: Waxes, a type of lipid, provide a waterproof barrier in plants and animals.

7. Amphipathic Nature: Many lipids, especially phospholipids, have both hydrophobic and hydrophilic regions, enabling them to form micelles and bilayers in aqueous environments.

8. Nutrient Absorption: Lipids aid in the absorption of fat-soluble vitamins (A, D, E, and K) in the digestive system.

4. What is the effect of non-competitive inhibitors on Vmax?

Non-competitive inhibitors affect the maximum velocity (Vmax) of an enzyme-catalyzed reaction. Specifically, they decrease the Vmax without changing the Michaelis constant (Km). Here's why this happens:

1. Binding Site: Non-competitive inhibitors bind to an allosteric site (a site other than the active site) on the enzyme. This binding changes the enzyme's shape or function, making it less effective at catalyzing the reaction, even when substrate concentration is high.

2. Vmax Decrease: Because the enzyme's activity is hindered regardless of how much substrate is present, the maximum rate of the reaction (Vmax) is lowered. The enzyme cannot convert substrate to product as quickly as it could without the inhibitor.

3. Km Unchanged: Since non-competitive inhibitors do not directly compete with the substrate for the active site, the affinity of the enzyme for the substrate (reflected by Km) remains the same. The substrate can still bind to the enzyme with the same affinity, but the overall number of active enzyme molecules available to catalyze the reaction is reduced.

5. Define selenocytine, its formation and function.

Selenocysteine is known as the 21st amino acid. It is unique among amino acids because it contains selenium, an essential trace element, incorporated into its structure. Here is a detailed overview of selenocysteine, its formation, and its function:

Structure and Characteristics:

Chemical Structure: Selenocysteine is similar to cysteine, but with a selenium atom replacing the sulfur atom in cysteine. Its structure can be represented as H-Se-CH2-CH(NH_2)-COOH.
Properties: The presence of selenium gives selenocysteine distinct chemical properties, making it more reactive than cysteine.

Formation:

1. Special tRNA: Selenocysteine is encoded by a specific tRNA, known as tRNA^[Sec], which has an anticodon that usually reads a stop codon (UGA).

2. Sec Incorporation: The process of incorporating selenocysteine into proteins requires several specialized factors:

- ***Selenocysteine Insertion Sequence (SECIS):*** A specific mRNA stem-loop structure called the SECIS element is necessary for the recognition of the UGA codon as a selenocysteine codon rather than a stop signal.
- ***Selenocysteine Synthase:*** An enzyme that helps synthesize selenocysteine on its specific tRNA.
- ***Selenophosphate Synthetase:*** This enzyme produces the active selenium donor, selenophosphate, necessary for the biosynthesis of selenocysteine.
- ***Elongation Factor:*** A specialized elongation factor (SelB in bacteria, eEFSec in eukaryotes) that delivers the charged tRNA^[Sec] to the ribosome in response to the SECIS element.

Function:

Redox Reactions: Selenocysteine is often found in the active sites of enzymes that are involved in redox reactions due to the unique redox properties of selenium. These enzymes include:

- ***Glutathione Peroxidases:*** Protect cells from oxidative damage by reducing hydrogen peroxide and organic hydroperoxides.
- ***Thioredoxin Reductases:*** Play a critical role in maintaining the redox balance within the cell by reducing thioredoxin.
- ***Deiodinases:*** Involved in thyroid hormone metabolism, regulating the conversion of thyroxine (T4) to triiodothyronine (T3), the active form of the hormone.

6. What is 2,3 biphosphoglycerate?

2,3-Bisphosphoglycerate (2,3-BPG) is a metabolite found in red blood cells that plays a crucial role in regulating hemoglobin's oxygen-binding affinity. By binding to deoxygenated hemoglobin, 2,3-BPG stabilizes its T-state (tense state), which lowers hemoglobin's affinity for oxygen and facilitates the release of oxygen to tissues. This mechanism ensures efficient oxygen delivery throughout the body, especially under conditions of hypoxia (low oxygen levels) or increased metabolic demand. The concentration of 2,3-BPG in red blood cells can adapt to various physiological conditions, such as high altitudes or chronic hypoxia, enhancing the body's ability to deliver oxygen where it is needed most.

7. Write properties of nitrogenous bases.

Nitrogenous bases, fundamental components of nucleic acids (DNA and RNA), exhibit several key properties that underpin their biological functions. Here are their primary properties:

1. Aromaticity: Nitrogenous bases are aromatic heterocycles, containing rings with alternating double bonds that confer stability and enable stacking interactions in the DNA and RNA structures.

2. Planarity: The planar structure of nitrogenous bases allows them to stack efficiently on top of each other, contributing to the stability of the nucleic acid double helix.

3. Hydrogen Bonding: Nitrogenous bases can form specific hydrogen bonds with complementary bases (A with T/U, and G with C). These hydrogen bonds are critical for the base pairing that holds the two strands of DNA together.

4. Hydrophobic Interactions: The largely hydrophobic nature of nitrogenous bases promotes their stacking interactions within the hydrophobic core of the DNA double helix, further stabilizing the nucleic acid structure.

5. Basicity: Nitrogenous bases are weak bases due to the presence of nitrogen atoms that can accept protons. This property is important for their participation in various biochemical processes.

6. UV Absorption: Nitrogenous bases absorb ultraviolet (UV) light, particularly around 260 nm, a property that is exploited in techniques for measuring nucleic acid concentration and purity.

7. Chemical Reactivity: The reactive sites on nitrogenous bases, such as the amino groups and ring nitrogens, allow them to participate in various biochemical reactions, including methylation and other modifications that regulate gene expression and function.

8. Base Pairing Specificity: Adenine (A) pairs with thymine (T) in DNA or uracil (U) in RNA through two hydrogen bonds, while guanine (G) pairs with cytosine (C) through three hydrogen bonds. This specificity is crucial for the accurate transmission of genetic information.

8. How inorganic compounds serve as cofactor?

Inorganic compounds serve as cofactors in enzymatic reactions by providing essential chemical functionalities that aid in catalysis. These cofactors can be metal ions (e.g., Mg^{2+}, Zn^{2+}, Fe^{2+}) or small molecules (e.g., ATP, NAD^{+}) that interact with enzymes to facilitate their function. Metal ions often stabilize enzyme structures, participate directly in catalytic reactions by coordinating substrates, and enable electron transfer processes critical for metabolism and other biochemical pathways. Small molecules like ATP provide energy for reactions, while coenzymes like NAD^{+} act as carriers of electrons or functional groups during enzymatic transformations. Overall, inorganic cofactors play diverse roles in enzymatic function, influencing substrate binding, reaction specificity, and overall enzyme activity in biological systems.

9. What is glycolysis?

Glycolysis is the central metabolic pathway responsible for the breakdown of glucose into pyruvate. It occurs in the cytoplasm of cells and is an anaerobic process, meaning it does not require oxygen. Glycolysis consists of a series of ten enzymatic reactions, each catalyzed by a specific enzyme, resulting in the conversion of one molecule of glucose (a six-carbon sugar) into two molecules of pyruvate (a three-carbon compound). Along the way, glycolysis produces ATP (adenosine triphosphate) and NADH (reduced nicotinamide adenine dinucleotide), which are energy carriers used by cells for various processes. Glycolysis is fundamental in both aerobic and anaerobic metabolism, serving as a key source of energy and precursor molecules for cellular functions.

10. Define condensation reaction with example.

A condensation reaction is a chemical reaction in which two molecules combine to form a larger molecule, typically with the loss of a smaller molecule like water, ammonia, or hydrogen chloride. This process results in the formation of a covalent bond between the molecules involved. Here's an example:

Example: The condensation of two molecules of ethanol (CH_3CH_2OH) to form ethyl acetate ($CH_3COOCH_2CH_3$):

In this reaction:
- Two molecules of ethanol (CH_3CH_2OH) combine.
- One molecule loses a hydroxyl group (-OH).
- The other molecule loses a hydrogen atom (-H).
- A new covalent bond forms between the remaining oxygen atom from ethanol and the carbon atom from acetic acid.
- Water (H_2O) is released as a byproduct.

This condensation reaction results in the formation of ethyl acetate (CH3COOCH2CH3), an ester, and exemplifies how condensation reactions contribute to the synthesis of larger molecules by eliminating a small molecule such as water.

11. Write composition of proteins.

Proteins are complex macromolecules composed of amino acid monomers linked together in long chains. The composition of proteins includes the following components:

1. Amino Acids: Proteins are built from amino acids, which are organic compounds containing an amino group (-NH2) and a carboxyl group (-COOH) bonded to a central carbon atom. There are 20 standard amino acids that can be arranged in different sequences to form a vast array of proteins.

2. Peptide Bonds: Amino acids are joined together through peptide bonds, which form between the amino group of one amino acid and the carboxyl group of another. This bond results in the formation of a peptide chain or polypeptide.

3. Primary Structure: The primary structure of a protein refers to the specific sequence of amino acids in the polypeptide chain. This sequence is dictated by the genetic code encoded in DNA.

4. Secondary Structure: Proteins can fold into regular structures such as alpha helices or beta sheets. These secondary structures result from hydrogen bonding between amino acids along the polypeptide chain.

5. Tertiary Structure: The tertiary structure of a protein refers to its overall three-dimensional shape, which is determined by interactions between amino acid side chains (R groups). These interactions include hydrogen bonding, disulfide bonds, hydrophobic interactions, and electrostatic interactions.

6. Quaternary Structure: Some proteins consist of multiple polypeptide chains (subunits) that come together to form a functional protein complex. The arrangement and interaction of these subunits constitute the quaternary structure of the protein.

7. Prosthetic Groups: In some proteins, non-protein components known as prosthetic groups are required for their function. These may include metal ions (e.g., iron in hemoglobin), coenzymes (e.g., heme in hemoglobin), or other small molecules that are tightly bound to the protein.

12. What is Induced fit hypothesis?

The induced fit model describes the dynamic interaction between an enzyme and its substrate during catalysis. Unlike the static "lock and key" model, this concept suggests that the enzyme's active site undergoes conformational changes upon substrate binding, leading to a more complementary fit. These changes optimize the alignment of functional groups and enhance the enzyme's catalytic activity. The induced fit model highlights the dynamic nature of enzyme-substrate interactions, emphasizing the flexibility of enzymes in adapting to their substrates to facilitate efficient catalysis.

13. Differentiate between Guanine and Adenine.

Guanine and adenine are both nitrogenous bases that are essential components of nucleic acids (DNA and RNA). Here are the key differences between guanine and adenine:

1. Chemical Structure:

Guanine: Guanine is a purine base with a chemical formula $C_5H_5N_5O$. It consists of a fused ring system containing four nitrogen atoms and five carbon atoms.
Adenine: Adenine is also a purine base with a chemical formula $C_5H_5N_5$. It has a similar fused ring structure to guanine, with four nitrogen atoms and five carbon atoms.

2. Pairing in DNA and RNA:

Guanine: In DNA and RNA, guanine pairs with cytosine (via three hydrogen bonds) on the opposite strand of the double helix.
Adenine: Adenine pairs with thymine in DNA (via two hydrogen bonds) or with uracil in RNA (also via two hydrogen bonds) on the opposite strand.

3. Functional Groups:

Guanine: Guanine has an amino group (-NH2) attached to the fused ring structure.
Adenine: Adenine has an amino group (-NH2) and an imine group (=NH) attached to the fused ring structure.

4. Role in Energy Carriers:

Both guanine and adenine are involved in the structure of energy carriers:
Guanine: It plays a role in the structure of guanosine triphosphate (GTP) and guanosine diphosphate (GDP).

Adenine: It is a part of adenosine triphosphate (ATP), adenosine diphosphate (ADP), and cyclic adenosine monophosphate (cAMP), which are critical in energy transfer and signal transduction processes.

14. Write function of AMP.

AMP, or adenosine monophosphate, serves several important functions within biological systems:

1. Energy Carrier: AMP is a component of adenosine triphosphate (ATP), which is the primary energy carrier in cells. During cellular respiration, ATP releases energy when its phosphate bonds are hydrolyzed to ADP (adenosine diphosphate) and AMP, providing energy for metabolic reactions.

2. Signaling Molecule: AMP can act as a signaling molecule in various cellular processes. For example, cyclic AMP (cAMP), derived from AMP, is a second messenger that mediates hormone and neurotransmitter signaling pathways, regulating processes such as gene expression, metabolism, and cell growth.

3. Regulation of Metabolism: AMP levels can serve as indicators of cellular energy status. High levels of AMP relative to ATP can activate AMP-activated protein kinase (AMPK), a key regulator of cellular energy homeostasis. AMPK promotes processes that generate ATP and inhibits ATP-consuming pathways, helping cells adapt to energy stress.

4. Precursor in Biosynthesis: AMP serves as a precursor for the synthesis of other nucleotides and coenzymes. For example, it can be phosphorylated to form ADP and ATP, or it can be used in the synthesis of nucleic acids (DNA and RNA) or coenzymes like NAD (nicotinamide adenine dinucleotide).

15. Write functions of triacylglycerol.

Triacylglycerols (triglycerides) serve several important functions in biological systems:

1. Energy Storage: Triacylglycerols are the main storage form of fatty acids and serve as a highly efficient energy reserve in organisms. They provide more than twice the energy per gram compared to carbohydrates or proteins when oxidized through cellular respiration.

2. Insulation and Thermal Regulation: In animals, triacylglycerols are stored in adipose tissue, where they provide thermal insulation and help regulate body temperature by insulating against heat loss.

3. Protection and Cushioning: Triacylglycerols can act as shock absorbers around organs, providing protection and cushioning against physical impact.

4. Metabolic Water Source: During metabolic breakdown, the oxidation of fatty acids in triacylglycerols produces water molecules, which can be metabolically useful in arid environments or during periods of water scarcity.

5. Hormonal Regulation: Triacylglycerols are involved in the synthesis and transport of hormones. For example, certain steroid hormones are derived from cholesterol, a precursor molecule derived from triacylglycerols.

6. Buoyancy and Buoyant Force: In aquatic animals, especially marine mammals like whales, blubber composed of triacylglycerols provides buoyancy, allowing them to float and conserve energy while swimming.

16. Explain Quaternary structure of proteins.

The quaternary structure of proteins refers to the spatial arrangement and interactions between multiple protein subunits (polypeptide chains) to form a functional protein complex. This level of protein structure is relevant only to proteins that consist of more than one polypeptide chain. Here's a detailed explanation of quaternary structure:

1. Composition: Proteins with quaternary structure are oligomeric, meaning they consist of two or more polypeptide subunits. These subunits may be identical (homodimers, homotrimers, etc.) or different (heterodimers, heterotrimers, etc.).

2. Interactions: The subunits in a quaternary structure are held together by various types of interactions, including:

- ***Non-covalent Interactions:*** Such as hydrogen bonds, ionic bonds, van der Waals forces, and hydrophobic interactions between amino acid residues on different subunits.
- ***Disulfide Bonds:*** Covalent bonds formed between cysteine residues on different subunits can provide additional stability to the complex.

3. Functional Significance: The assembly of multiple subunits into a quaternary structure often enhances the functional capabilities of the protein complex:

- ***Allosteric Regulation:*** Some proteins exhibit allosteric regulation, where binding of a molecule to one subunit affects the activity of another subunit within the complex.
- ***Enhanced Specificity:*** Proteins with quaternary structure may have multiple active sites or binding sites, allowing for more specific interactions with ligands or substrates.
- ***Cooperative Binding:*** Subunits within a protein complex may cooperatively bind ligands or substrates, leading to enhanced efficiency or regulation of enzymatic activities.

4. Examples: Many proteins exhibit quaternary structure, including enzymes (e.g., hemoglobin, which consists of four subunits), transport proteins (e.g., ion channels), and antibodies (which consist of two heavy chains and two light chains).

5. Stabilization: Quaternary structure provides stability to the protein complex and often protects the individual subunits from denaturation or degradation.

17. Define Alpha, Beta and Gamma carbon.

The terms alpha, beta, and gamma carbon refer to specific carbon atoms within a molecule, particularly in organic chemistry and biochemistry:

1. Alpha Carbon: In organic molecules, the alpha carbon (α-carbon) is the carbon atom directly attached to a functional group, such as a carbonyl group (C=O) or an amino group (NH2). It is the carbon atom closest to the functional group in the molecule's structure.

2. Beta Carbon: The beta carbon (β-carbon) is the carbon atom adjacent to the alpha carbon. In other words, it is the second carbon atom in the chain extending from the alpha carbon.

3. Gamma Carbon: Similarly, the gamma carbon (γ-carbon) is the carbon atom adjacent to the beta carbon, or the third carbon atom in the chain extending from the alpha carbon.

18. What is number of carbon and nitrogen in nitrogenous bases?

Nitrogenous bases, which are essential components of nucleic acids (DNA and RNA), contain both carbon and nitrogen atoms. Here's the typical composition of carbon and nitrogen in nitrogenous bases:

1. Pyrimidine Bases:
Cytosine (C): Contains 4 carbon atoms and 3 nitrogen atoms.
Thymine (T, in DNA): Contains 5 carbon atoms and 3 nitrogen atoms.
Uracil (U, in RNA): Contains 4 carbon atoms and 2 nitrogen atoms.

2. Purine Bases:
Adenine (A): Contains 5 carbon atoms and 5 nitrogen atoms.
Guanine (G): Contains 5 carbon atoms and 5 nitrogen atoms.

19. Write characteristics of VLDL.

Very Low-Density Lipoprotein (VLDL) is a type of lipoprotein primarily responsible for transporting triglycerides (TG) synthesized in the liver to peripheral tissues. Here are the key characteristics of VLDL:

1. Composition: VLDL particles consist of a core of triglycerides (TG), cholesterol esters, and fat-soluble vitamins surrounded by a single layer of phospholipids, free cholesterol, and apolipoproteins.

2. Density: VLDL has a density of approximately 0.95 to 1.006 g/mL, which is lower than that of Low-Density Lipoprotein (LDL) and High-Density Lipoprotein (HDL).

3. Size: VLDL particles are larger than LDL and HDL, with diameters typically ranging from 30 to 80 nanometers.

4. Function: The primary function of VLDL is to transport endogenous triglycerides synthesized in the liver to various tissues, where they can be hydrolyzed by lipoprotein lipase (LPL) to release free fatty acids for energy metabolism or storage.

5. Metabolism:

- In liver, triglycerides & apolipoprotein B-100 (apoB-100) are assembled to form VLDL.

- VLDL particles are released into the bloodstream, where they undergo lipolysis mediated by LPL in peripheral tissues.
- The remnants of VLDL (IDL, Intermediate-Density Lipoprotein) are further metabolized into LDL, which delivers cholesterol to tissues or is taken up by the liver.

6. Apolipoproteins: VLDL particles contain apolipoprotein B-100 (apoB-100), which plays a crucial role in binding to LDL receptors and facilitating lipid transport and metabolism.

7. Clinical Significance: Elevated levels of VLDL cholesterol (VLDL-C) in the blood are associated with increased risk of cardiovascular diseases, particularly when accompanied by high levels of LDL cholesterol and low levels of HDL cholesterol.

20. Explain types of RNA.

RNA (ribonucleic acid) is a versatile molecule involved in various essential biological processes, classified into several types based on their structure and function. Here are main types of RNA:

1. Messenger RNA (mRNA):

mRNA carries genetic information from DNA in the nucleus to ribosomes in the cytoplasm, where it serves as a template for protein synthesis (translation). mRNA molecules are single-stranded and are transcribed from DNA by RNA polymerase enzymes. They contain codons, sequences of three nucleotides that specify the amino acids to be incorporated into proteins.

2. Transfer RNA (tRNA):

tRNA molecules are responsible for delivering amino acids to the ribosome during protein synthesis. Each tRNA molecule recognizes a specific codon on the mRNA through its anticodon sequence and carries the corresponding amino acid. tRNA molecules are L-shaped and fold into a cloverleaf structure with specific regions: the anticodon loop, amino acid attachment site (acceptor stem), and variable loop. They are typically about 70-90 nucleotides long.

3. Ribosomal RNA (rRNA):

rRNA is a structural component of ribosomes, the cellular organelles where protein synthesis occurs. It catalyzes the formation of peptide bonds between amino acids during translation. rRNA molecules are the most abundant type of RNA and constitute the bulk of ribosomes. They are composed of two subunits, large and small, each containing rRNA molecules and proteins.

4. Small Nuclear RNA (snRNA):

snRNAs are involved in RNA splicing, a process where non-coding regions (introns) are removed from pre-mRNA molecules and exons are joined together to form mature mRNA. snRNAs are small (100-300 nucleotides) and found in the cell nucleus, where they associate with proteins to form small nuclear ribonucleoprotein particles (snRNPs).

5. MicroRNA (miRNA):

miRNAs regulate gene expression by binding to complementary sequences on mRNA molecules, leading to mRNA degradation or inhibition of translation. They play roles in development, differentiation, and various cellular processes. miRNAs are short (about 21-25 nucleotides) and are processed from longer RNA precursors by enzymes called Dicer and Drosha.

6. Long Non-Coding RNA (lncRNA):

lncRNAs are longer RNA molecules (over 200 nucleotides) that do not encode proteins but have regulatory functions in gene expression, chromatin remodeling, and other cellular processes. lncRNAs have diverse structures and functions, often interacting with proteins, DNA, or other RNAs to exert their regulatory roles.

21. Explain enzyme kinetics.

Enzyme kinetics is the study of how enzymes catalyze chemical reactions. It involves understanding the rates at which enzymes convert substrates into products and the factors that influence these rates. Key concepts include substrate binding to enzyme active sites, formation of enzyme-substrate complexes, and factors like substrate concentration, enzyme concentration, temperature, and pH that affect reaction rates. The Michaelis-Menten equation describes enzyme kinetics, with parameters such as Km (Michaelis constant) and Vmax (maximum reaction velocity) characterizing enzyme-substrate interactions. Enzyme kinetics is essential for understanding enzyme mechanisms, designing experiments, and predicting enzyme behavior in biological systems.

22. Differentiate between Uracil and Thymine.

Uracil and thymine are nitrogenous bases found in nucleic acids, specifically RNA and DNA, respectively. Here are the main differences between uracil and thymine:

1. Occurrence:

Uracil: Found in RNA as one of the four bases (adenine, cytosine, guanine, and uracil).
Thymine: Found in DNA as one of the four bases (adenine, cytosine, guanine, and thymine).

2. Chemical Structure:

Both uracil and thymine are pyrimidine bases, meaning they have a single-ring structure with nitrogen atoms.

3. Function:

Uracil: In RNA, uracil pairs with adenine (A) via two hydrogen bonds during transcription and translation processes.
Thymine: In DNA, thymine pairs with adenine (A) via two hydrogen bonds during DNA replication and transcription.

4. Presence of Methyl Group:

Thymine: Unlike uracil, thymine has a methyl group (-CH3) attached to its ring structure.

5. Biosynthesis and Regulation:

Thymine is synthesized from uracil through a methylation process catalyzed by the enzyme thymidylate synthase.

23. How activation energy effect the rate of reaction?

Activation energy plays a crucial role in determining the rate of a chemical reaction. Here’s how it affects reaction rates:

1. Activation Energy Definition: Activation energy (Ea) is the minimum amount of energy that reactant molecules must possess to undergo a chemical reaction and form products. It represents the energy barrier that must be overcome for the reaction to proceed.

2. Effect on Reaction Rate:

Lower Activation Energy: When the activation energy of a reaction is lower, a larger fraction of the reactant molecules possesses sufficient energy to overcome the energy barrier and react. As a result, the reaction rate increases because more collisions between reactant molecules are successful in forming products.

Higher Activation Energy: Conversely, when the activation energy is higher, fewer reactant molecules have enough energy to overcome the barrier. This leads to a lower reaction rate because fewer collisions result in successful reactions.

3. Catalysts: Catalysts are substances that lower the activation energy of a reaction by providing an alternative reaction pathway with a lower energy barrier. By lowering Ea, catalysts increase the rate of reaction without being consumed in the process. They achieve this by stabilizing transition states or providing alternative reaction mechanisms that require less energy to proceed.

4. Temperature Dependence: Increasing temperature generally increases the kinetic energy of molecules, leading to more frequent and energetic collisions between reactants. This effectively increases the number of molecules with energies exceeding the activation energy, thereby increasing the reaction rate.

24. Discuss role of protein in respiration.

Here are the roles of proteins in cellular respiration:

Enzymes: Catalyze specific reactions in metabolic pathways like glycolysis, the citric acid cycle, and the electron transport chain.

Electron Carriers: Proteins such as cytochromes and flavoproteins transport electrons along the electron transport chain (ETC).

ATP Synthase: Protein complex that synthesizes ATP using the proton gradient generated by the ETC.

Regulation: Proteins regulate enzymatic activity through feedback mechanisms, allosteric regulation, and phosphorylation.

Transport: Proteins transport molecules and ions across membranes, maintaining gradients essential for respiration.

25. Differentiate between nucleotide and nucleoside.

Here's the differentiation between nucleotide and nucleoside:

1. Nucleotide:

Composition: A nucleotide consists of three main components: A nitrogenous base (either adenine, guanine, cytosine, thymine (in DNA), uracil (in RNA)). A five-carbon sugar molecule (ribose in RNA or deoxyribose in DNA). One or more phosphate groups (typically one, forming monophosphate, diphosphate, or triphosphate nucleotides).

Structure: The nitrogenous base is attached to the 1' carbon of the sugar molecule, while the phosphate group(s) are attached to the 5' carbon of the sugar.
Function: Nucleotides serve as the building blocks of nucleic acids (DNA and RNA) and play essential roles in cellular metabolism (e.g., ATP, GTP, cAMP).

2. Nucleoside:

Composition: A nucleoside consists of two main components: A nitrogenous base (adenine, guanine, cytosine, thymine, or uracil). A five-carbon sugar molecule (ribose in RNA or deoxyribose in DNA).
Structure: Unlike nucleotides, nucleosides do not contain phosphate groups.
Function: Nucleosides are involved in the synthesis of nucleotides. They can also have roles as signaling molecules (e.g., adenosine in neurotransmission) or as components of cofactors (e.g., NAD+).

26. Explain simple lipids and its types.

Simple lipids, also known as neutral fats, are esters composed of fatty acids and various alcohols. They serve primarily as energy storage molecules. Here are the types:

1. Triglycerides: Consist of three fatty acids esterified to a glycerol molecule, stored in adipose tissue for energy.

2. Waxes: Esterified fatty acids with long-chain alcohols, providing waterproofing and protective coatings.

3. Sterol Esters: Fatty acids esterified with sterols (e.g., cholesterol), serving as storage forms and structural components in cells.

27. What is Zero Order Reaction?

A zero-order reaction is a type of chemical reaction where the rate of reaction is independent of the concentration of the reactants. In other words, the reaction proceeds at a constant rate over time, unaffected by changes in reactant concentrations. The rate law for a zero-order reaction is expressed as Rate = k, where k is the rate constant. Examples include certain enzyme-catalyzed reactions at high substrate concentrations and decomposition reactions where other factors limit the rate besides reactant concentration.

28. Write functions of tRNA.

Amino Acid Delivery: Transports amino acids to ribosomes during protein synthesis.
Anticodon Recognition: Contains an anticodon sequence that base-pairs with mRNA codons, ensuring correct amino acid incorporation.
Adaptor Molecule: Acts as an adaptor between mRNA codons and amino acids, facilitating protein synthesis.
Ribosomal Binding: Binds to ribosomes, positioning the amino acid in place for peptide bond formation.
Translocation: Participates in the translocation step of protein synthesis, moving the ribosome along mRNA to elongate the polypeptide chain.

29. Describe the importance of Sorbitol.

- ***Sweetener:*** Used as a low-calorie sweetener in sugar-free and reduced-sugar foods and beverages.
- ***Humectant:*** Retains moisture and improves texture in cosmetics, personal care products, and food items like candies.
- ***Laxative:*** Acts as an osmotic laxative to relieve constipation by drawing water into the colon.
- ***Medical Applications:*** Included in pharmaceutical formulations and IV solutions for stability and tonicity adjustment.
- ***Industrial Uses:*** Serves as a chemical intermediate in the production of ascorbic acid (vitamin C) and surfactants, and as a plasticizer in plastics manufacturing.

30. What are the common dienoic acids and also write their family name.

Dienoic acids are fatty acids containing two double bonds in their hydrocarbon chain. Here are some common dienoic acids along with their family names:

1. Linoleic Acid:

- ***Family Name:*** Omega-6 fatty acid
- ***Structure:*** 18:2 (9,12) - Contains double bonds at the 9th and 12th carbon atoms from the carboxylic acid end.

2. Alpha-Linolenic Acid:

- ***Family Name:*** Omega-3 fatty acid
- ***Structure:*** 18:3 (9,12,15) - Contains double bonds at the 9th, 12th, and 15th carbon atoms from the carboxylic acid end.

31. How the carbon atoms are numbered in Pentose sugar of both nucleotides and nucleosides?

In both nucleotides and nucleosides, the carbon atoms in the pentose sugar (ribose or deoxyribose) are numbered conventionally from 1 to 5. Here's how the carbon atoms are typically numbered:

1. Ribose (in RNA):

Carbon 1 (C1): Attached to the nitrogenous base via a glycosidic bond.
Carbon 2 (C2): Hydrogen atom attached.
Carbon 3 (C3): Hydroxyl group (-OH) attached.
Carbon 4 (C4): Hydrogen atom attached.
Carbon 5 (C5): Phosphate group attached in nucleotides (forming nucleotides) or free in nucleosides (forming nucleosides).

2. Deoxyribose (in DNA):

Carbon 1 (C1): Attached to the nitrogenous base via a glycosidic bond.
Carbon 2 (C2): Hydrogen atom attached.
Carbon 3 (C3): Hydroxyl group (-OH) replaced by a hydrogen atom.

Carbon 4 (C4): Hydrogen atom attached.
Carbon 5 (C5): Phosphate group attached in nucleotides (forming nucleotides) or free in nucleosides (forming nucleosides).

32. What are lyases?

Lyases are a class of enzymes that catalyze the cleavage or formation of chemical bonds without the direct involvement of water. They participate in reactions where functional groups are added to double bonds or where double bonds are broken. Here are some key points about lyases:

1. Reaction Type: Lyases catalyze reactions that involve the elimination of groups to form double bonds (elimination reactions) or the addition of groups to double bonds (addition reactions).

2. Substrate Specificity: They act on a variety of substrates, including carbohydrates, nucleic acids, and proteins, facilitating structural changes or the synthesis of new compounds.

3. Coenzyme Dependence: Many lyases require coenzymes or cofactors to assist in catalysis, providing additional specificity and efficiency to the reactions they catalyze.

4. Biological Importance: Lyases play critical roles in various metabolic pathways, such as glycolysis, the citric acid cycle, and the biosynthesis of important molecules like amino acids and nucleotides.

5. Examples:
Decarboxylases: Catalyze the removal of a carboxyl group from a substrate.
Dehydratases: Catalyze the removal of water from a substrate to form a double bond.
Aldolases: Catalyze the cleavage or formation of carbon-carbon bonds in aldol reactions.

33. What is the distribution of waxes naturally?

Waxes are naturally distributed across various organisms and environments, serving diverse functions. Here's how they are distributed in nature:

1. Plants:
Cuticular Waxes: Found on the surface of leaves, fruits, and stems, forming a protective barrier against water loss, UV radiation, and pathogens.
Epicuticular Waxes: Coating the outer surface of plant organs, contributing to their water-repellent properties and reducing surface tension.

2. Animals:
Wax Esters: Produced by specialized glands in certain animal species, such as bees (beeswax), where they form the structural matrix of honeycombs.
Sebaceous Glands: Secretion of wax esters in mammals (e.g., earwax in humans) for lubrication and protection of skin and hair.

3. Insects:

Cuticular Waxes: Coating the exoskeleton of insects, providing waterproofing and protection against desiccation.

4. Marine Organisms:

Wax Esters: Produced by marine organisms like plankton and fish to regulate buoyancy, provide energy storage, and maintain waterproofing.

5. Fungi:

Epicuticular Waxes: Found on the fruiting bodies of fungi, contributing to their water resistance and protection.

6. Microorganisms:

Cell Membranes: Some microorganisms incorporate waxes into their cell membranes to maintain integrity and function in extreme environments.

34. What is Michaelis-Mentes constant Km?

The Michaelis constant (Km) is a fundamental parameter in enzyme kinetics that quantifies the affinity of an enzyme for its substrate. It represents the substrate concentration at which the rate of the enzymatic reaction is half of its maximum velocity (Vmax). In other words, Km reflects how tightly the enzyme binds to its substrate. Enzymes with a low Km value have high affinity for their substrate, meaning they achieve half-maximal velocity at lower substrate concentrations. Conversely, enzymes with a high Km value have lower affinity, requiring higher substrate concentrations to achieve the same half-maximal velocity. Understanding Km is essential in studying enzyme specificity, catalytic efficiency, and the effects of inhibitors, providing insights into the dynamics and regulation of biochemical reactions in living organisms.

35. What are the allosteric effects of hemoglobin?

Hemoglobin exhibits allosteric effects, meaning its binding affinity for oxygen is influenced by factors other than oxygen itself. Here are the key allosteric effects of hemoglobin:

1. Positive Allosteric Effectors:

Protons (H+): Low pH (acidic conditions) promotes the release of oxygen from hemoglobin, facilitating oxygen unloading in tissues where pH is lower due to increased metabolic activity.

Carbon Dioxide (CO2): Elevated CO2 levels decrease hemoglobin's affinity for oxygen, enhancing oxygen release in tissues. CO2 binds to the globin portion of hemoglobin, forming carbaminohemoglobin, which stabilizes the T-state conformation (deoxyhemoglobin).

2. Negative Allosteric Effectors:

Bisphosphoglycerate (BPG): BPG binds to the central cavity of hemoglobin in its deoxy (T-state) form, reducing its oxygen affinity. This promotes oxygen release in tissues with high metabolic rates, such as during exercise or at high altitudes.

36. Write the five physical properties of triacylglycerol.

Here are the five physical properties of triacylglycerols (triglycerides):

State at Room Temperature:

Solid or liquid form depending on fatty acid composition. Saturated fats are typically solid (e.g., butter). Unsaturated fats can be liquid (e.g., olive oil).

Melting Point:

Varies based on fatty acid chain length and saturation. Saturated fats have higher melting points. Unsaturated fats (especially cis-double bonds) have lower melting points.

Solubility:

Insoluble in water (hydrophobic) but soluble in nonpolar solvents (e.g., ether, chloroform). They have nonpolar nature due to fatty acid chains.

Density:

Lower density compared to water. Contributes to buoyancy in aqueous environments.

Appearance:

Clear and transparent in liquid form (oils). No light-scattering structures.

37. What do you know about N-glycosidic linkage? How it is formed?

An N-glycosidic linkage is a covalent bond between a nitrogenous base (such as adenine, guanine, cytosine, thymine, or uracil) and the C1' carbon of a sugar (ribose or deoxyribose) in nucleosides or nucleotides. It is formed through a condensation reaction, where the hydroxyl group (-OH) on the C1' carbon of the sugar reacts with the nitrogenous base, resulting in the release of water. This bond is crucial for the structure and function of nucleic acids (DNA and RNA), providing stability and enabling base pairing during genetic processes.

38. What is the effect of pH on an ionized state of active site?

The effect of pH on the ionized state of the active site in enzymes is crucial for their function and catalytic activity. Here’s a concise explanation:

Ionizable Groups: Many enzymes contain amino acid residues (such as histidine, lysine, aspartate, and glutamate) within their active sites that can ionize depending on the pH of the surrounding environment.

Optimal pH: Enzymes typically have an optimal pH range where they exhibit maximum catalytic activity. This optimal pH often corresponds to the pH where the ionizable groups in the active site are in their optimal ionization state for substrate binding and catalysis.

pH and Charge: pH affects the charge distribution on ionizable groups. At low pH (acidic conditions), ionizable groups tend to be protonated (positively charged), whereas at high pH (basic conditions), they tend to be deprotonated (negatively charged). The ionization state of these groups can influence enzyme-substrate interactions and catalytic mechanisms.

Activity and Stability: Deviation from the optimal pH range can reduce enzyme activity and stability. Extreme pH conditions can denature enzymes by disrupting their active site structure or altering the charge distribution of critical residues.

39. What are buffers? Write their composition.

Buffers are solutions that resist changes in pH when small amounts of acid or base are added to them. They are essential in maintaining stable pH conditions in biological systems, chemical reactions, and various laboratory procedures. Here's an overview of their composition and function:

Composition: Buffers typically consist of a weak acid and its conjugate base (or a weak base and its conjugate acid). This combination allows them to neutralize excess hydrogen ions (H+) or hydroxide ions (OH-) in a solution, thereby maintaining a relatively constant pH.

- Examples of Buffers:

1. Acetate Buffer:

Composition: Acetic acid (weak acid) and sodium acetate (conjugate base).

Function: Effective around pH 4.7.

2. Phosphate Buffer:

Composition: Dihydrogen phosphate (H2PO4-) and hydrogen phosphate (HPO4^2-).

Function: Effective in the pH range of 6.8 to 7.8.

3. Tris Buffer (Tris-HCl):

Composition: Tris(hydroxymethyl)aminomethane (weak base) and hydrochloric acid.

Function: Effective around pH 7.5 to 9.0.

Mechanism: Buffers work by utilizing the equilibrium between the weak acid and its conjugate base (or vice versa) to absorb or release hydrogen ions in response to changes in pH. This helps to stabilize the pH of a solution and maintain optimal conditions for biochemical reactions and other processes.

Applications: Buffers are widely used in biological sciences, medicine, and analytical chemistry to control pH in enzymatic reactions, cell culture media, biochemical assays, and laboratory experiments where maintaining a specific pH is critical for accurate results.

40. How oil is formed from Ghee?

Oil can be formed from ghee through a process where ghee is heated to a high temperature. During heating, the water content and any remaining milk solids in ghee evaporate, leaving behind the pure fat component. This fat, which is now in liquid form due to the heat, is what we commonly refer to as oil. Therefore, heating ghee sufficiently causes it to transform into oil, suitable for various cooking and culinary uses.

41. Explain rate of reaction in relation to substrate concentration.

The rate of reaction increases with increasing substrate concentration until it reaches a point of saturation. At low substrate concentrations, the rate of reaction is directly proportional to substrate availability. As substrate concentration increases, enzyme active sites become saturated, leading to a plateau where further increases do not significantly increase the reaction rate. This relationship is described by the Michaelis-Menten equation in enzyme kinetics.

42. Write functions of mRNA.

mRNA (messenger RNA) plays several crucial roles in the process of protein synthesis within cells. Here are its main functions:

Transcription: mRNA is synthesized during transcription, where a complementary RNA strand is produced from a DNA template in the nucleus.

Genetic Code Carrier: It carries the genetic information from the DNA in the nucleus to the ribosomes in the cytoplasm or rough endoplasmic reticulum, where protein synthesis occurs.

Translation Template: mRNA serves as a template for translation, guiding the assembly of amino acids into a specific sequence to form proteins.

Regulation of Gene Expression: It plays a role in regulating gene expression by controlling which genes are transcribed into mRNA molecules.

Degradation: mRNA molecules have a finite lifespan and are eventually degraded by cellular machinery, allowing for dynamic regulation of protein production.

43. Define amylase.

Amylase is an enzyme that catalyzes the hydrolysis (breakdown) of starch and glycogen into smaller polysaccharides, maltose, and glucose. It is produced in various organisms, including humans (salivary amylase and pancreatic amylase), plants, and microorganisms. Here's a short note on amylase:

Function: Amylase facilitates the digestion of complex carbohydrates (starches and glycogen) into simpler sugars that can be absorbed and utilized by cells.

Types:
Alpha-Amylase: Acts on internal α-1,4 glycosidic bonds within starch molecules, breaking them down into maltose and other oligosaccharides.
Beta-Amylase: Catalyzes the hydrolysis of the non-reducing end of starch and glycogen molecules, releasing maltose.

Sources: Found in saliva (salivary amylase) and pancreatic secretions (pancreatic amylase) in humans, as well as in plants and microorganisms where it aids in carbohydrate metabolism.

Industrial Applications: Used in various industrial processes, such as in food and beverage production (e.g., brewing, baking) and in the production of biofuels from starch-containing crops.

Medical Importance: Measurement of amylase levels in blood or urine can be used as diagnostic markers for certain medical conditions, including pancreatitis and other pancreatic disorders.

44. Explain secondary structure of Protein.

The secondary structure of proteins refers to the local folding patterns and arrangements of the polypeptide backbone. These structures are stabilized primarily by hydrogen bonds between the backbone atoms, creating recurring spatial arrangements that give proteins their characteristic shapes. Here's a concise explanation of the two main types of secondary structures:

1. Alpha Helix:

Structure: The alpha helix is a right-handed coil where the polypeptide backbone forms a spiral structure stabilized by hydrogen bonds between the carbonyl oxygen of one amino acid residue and the amide hydrogen of another, four residues ahead in the sequence.

Characteristics: It is compact and rigid, with 3.6 amino acid residues per turn and a rise of 1.5 angstroms per residue along the helical axis.

Examples: Found commonly in fibrous proteins like keratin and in the secondary structures of globular proteins.

2. Beta Sheet:

Structure: Beta sheets consist of extended polypeptide strands (beta strands) that are aligned next to each other and stabilized by hydrogen bonds between the carbonyl oxygen of one strand and the amide hydrogen of an adjacent strand.

Characteristics: Strands can be parallel (with all N-termini and C-termini aligned) or antiparallel (with alternating N- and C-termini), forming a pleated, sheet-like structure.

Examples: Found in the core of many globular proteins and in the structure of fibrous proteins like silk.

45. Explain Histidine.

Histidine is an essential amino acid involved in protein structure, enzyme function (as a metal-binding site), and neurotransmitter synthesis. It's classified as basic due to its positively charged imidazole group at physiological pH.

46. Write importance of Alanine and Valine.

Alanine:

Metabolism: Alanine plays a crucial role in glucose-alanine cycle, transporting amino groups to the liver.

Energy: It provides energy during exercise and plays a key role in glucose metabolism.

Protein synthesis: It's vital for synthesizing proteins and is involved in neurotransmitter production.

Valine:

Muscle metabolism: It is involved in muscle growth, repair, and energy production.

Brain function: Valine helps regulate the nervous system and cognitive functions.

Immune function: It is important for maintaining the immune system and overall health

47. Differentiate between coenzyme and cofactor.

Coenzyme and cofactor are both essential components for the proper functioning of enzymes, but they differ in their nature and how they interact with enzymes:

Cofactor:

Definition: A cofactor is a non-protein chemical compound or ion that is required for the activity of an enzyme. It can be either inorganic (like metal ions) or organic (like coenzymes).

Function: Cofactors often assist enzymes by providing chemical groups that participate in catalysis. They may help in stabilizing enzyme-substrate complexes or in mediating redox reactions.

Examples: Zinc ion ($Zn2+$) in carbonic anhydrase, magnesium ion ($Mg2+$) in ATPases.

Coenzyme:

Definition: A coenzyme is a type of cofactor that is loosely bound to an enzyme and is often derived from vitamins or other organic compounds. Coenzymes participate in enzyme catalysis by carrying chemical groups or electrons between enzymes and reactions.

Function: Coenzymes often act as carriers of specific functional groups, such as hydrogen atoms, electrons, or acyl groups, which are necessary for enzyme activity. They are usually recycled and reused in different enzymatic reactions.

Examples: NAD+ (nicotinamide adenine dinucleotide), FAD (flavin adenine dinucleotide), coenzyme A.

Key Differences:

Nature: Cofactors can be either inorganic or organic, while coenzymes are organic compounds derived from vitamins or other dietary sources.

Binding: Cofactors can be tightly or loosely bound to enzymes, whereas coenzymes are typically loosely bound and can dissociate from the enzyme after catalysis.

Role: Cofactors generally provide structural or catalytic support to enzymes, while coenzymes specifically carry and transfer chemical groups necessary for enzyme function.

48. What is role of protein in Hem group?

Structural Support: Provides a scaffold to hold and orient the heme group.

Stabilization: Protects the heme group from damage and degradation.

Oxygen Binding and Transport: Facilitates oxygen binding to the iron atom in the heme group and its release (e.g., hemoglobin, myoglobin).

Electron Transfer: Aids in the transfer of electrons in electron transport chains (e.g., cytochromes).

Regulation: Modulates heme group activity through allosteric effects and conformational changes.

Catalysis: Supports catalytic activity in heme-containing enzymes (e.g., catalases, peroxidases).

49. Write function of cyclic AMP.

Cyclic AMP (cAMP) functions as a second messenger in cellular signaling, relaying signals from extracellular stimuli (like hormones) to intracellular targets, thereby regulating processes such as metabolism, gene expression, and cell growth.

50. Write domains in protein.

Protein domains are distinct structural and functional units within a protein. Here are some common types of protein domains:

Catalytic Domains: Regions responsible for the enzyme's catalytic activity, often containing the active site where substrate binding and chemical reactions occur.

Binding Domains: Areas that facilitate binding to other molecules, such as DNA, RNA, proteins, or small ligands.

Regulatory Domains: Segments that regulate the protein's activity, often through conformational changes or interactions with other molecules.

Transmembrane Domains: Hydrophobic regions that span cell membranes, anchoring the protein and facilitating interactions across the membrane.

Signal Domains: Parts involved in signal transduction, helping relay messages within and between cells.

Motifs: Short, recurring sequences within domains that contribute to the domain's specific function, such as zinc fingers or leucine zippers.

51. What are grooves in DNA double helix?

In the DNA double helix, grooves are indentations that run along the length of the molecule, formed by the twisting of the two DNA strands around each other. Two types are:

1. Major Groove:

Description: The wider of the two grooves, occurring where the backbones of the DNA strands are farthest apart.

Function: Provides a binding site for many DNA-binding proteins, including transcription factors, which can recognize specific base sequences through the exposed edges of the bases.

2. Minor Groove:

Description: The narrower groove, occurring where the backbones of the DNA strands are closest together.

Function: Also serves as a binding site for proteins and small molecules, but with less sequence specificity compared to the major groove.

52. Write components of nucleotides.

Nucleotides, building blocks of nucleic acids (DNA and RNA), consist of three main components:

1. Nitrogenous Base:

Purines: Adenine (A) and Guanine (G)

Pyrimidines: Cytosine (C), Thymine (T) in DNA, and Uracil (U) in RNA

2. Pentose Sugar:

Deoxyribose is present in DNA while Ribose in RNA.

3. Phosphate Group:

One or more phosphate groups attached to the 5' carbon of the pentose sugar

53. Explain primary structure of protein.

The primary structure of a protein is the linear sequence of amino acids linked together by peptide bonds, forming a polypeptide chain. This sequence determines the protein's unique characteristics and dictates its higher-level structures and functions.

54. Explain structure of DNA.

The structure of DNA (deoxyribonucleic acid) is a double helix, a term that describes the twisted ladder-like shape of the molecule. Here are the key features of its structure:

1. Double Helix:

Shape: DNA consists of two long strands that twist around each other to form a double helix.

Orientation: The strands are antiparallel, meaning they run in opposite directions (one 5' to 3' and the other 3' to 5').

2. Backbone:

Composition: Each DNA strand has a backbone made of alternating sugar (deoxyribose) and phosphate groups.

Linkage: The sugar and phosphate groups are connected by phosphodiester bonds.

3. Nitrogenous Bases:

Types: There are four types of nitrogenous bases in DNA. Purines that are Adenine (A) and Guanine (G) and Pyrimidines include Cytosine (C) and Thymine (T).

Base Pairing: The bases pair through hydrogen bonds to form the rungs of the ladder. Adenine pairs with Thymine (A-T) via two hydrogen bonds. Guanine pairs with Cytosine (G-C) via three hydrogen bonds.

4. Major and Minor Grooves:

Grooves: The helical structure creates alternating major and minor grooves along the DNA molecule.

Major Groove: The wider groove, which provides a binding site for proteins that interact with DNA.

Minor Groove: The narrower groove, which also allows protein binding but is less accessible than the major groove.

5. Base Stacking:

Stability: The nitrogenous bases stack on top of each other within the helix, providing additional stability through hydrophobic interactions and van der Waals forces.

6. Antiparallel Strands:

Directionality: The two strands run in opposite directions, which is critical for the replication and transcription processes.

7. Complementary Base Pairing:

Specificity: The specific pairing of bases (A with T and G with C) ensures accurate replication and transcription of genetic information.

55. What is Hydrogenation?

Hydrogenation is a chemical reaction where hydrogen (H_2) is added to unsaturated organic compounds, typically in the presence of a catalyst such as nickel, palladium, or platinum, resulting in the conversion of double or triple bonds to single bonds. This process is widely used in the food industry to convert liquid oils into solid fats and in the chemical industry to produce saturated hydrocarbons and other chemicals.

56. Discuss dissociation of amino acids of Alanine.

The dissociation of alanine involves the ionization of its amino and carboxyl groups at different pH levels:

- At low pH (acidic conditions): The amino group is protonated ($-NH_3^+$) and the carboxyl group is not dissociated (-COOH), resulting in a positively charged molecule.

- At physiological pH (~7.4): Alanine exists as a zwitterion, where the amino group is protonated ($-NH_3^+$) and the carboxyl group is deprotonated ($-COO^-$), resulting in no net charge.

- At high pH (basic conditions): The amino group loses a proton ($-NH_2$), and the carboxyl group is deprotonated ($-COO^-$), resulting in a negatively charged molecule.

The key pKa values for alanine are approximately 2.34 for the carboxyl group and 9.69 for the amino group, indicating the pH at which each group gains or loses a proton.

57. Why glycine does not occur in alpha helix?

Glycine does not frequently occur in alpha helices primarily due to its unique structural properties:

<u>1. Flexibility:</u>
Structural Simplicity: Glycine has a hydrogen atom as its side chain, making it the smallest and most flexible amino acid. This flexibility allows for greater conformational freedom, which can disrupt the regularity and stability of the alpha helix structure.

<u>2. Lack of Steric Hindrance:</u>
Steric Considerations: Most amino acids have bulkier side chains that help maintain the helical structure through steric interactions. Glycine's small side chain provides little steric hindrance, making it less effective at maintaining the tight, orderly structure of the alpha helix.

<u>3. Helix-Disrupting Tendencies:</u>
Disruption of Helical Structure: Due to its flexibility and lack of steric hindrance, glycine can introduce kinks or bends in the helix, destabilizing it. This disrupts the regular hydrogen bonding pattern essential for the alpha helix's stability.

<u>4. Preferred Locations:</u>
Helix Termini and Loops: Glycine is more commonly found at the ends of alpha helices or in loop regions where flexibility is advantageous. These regions benefit from glycine's ability to adopt various conformations without destabilizing the protein's overall structure.

58. Differentiate between template and non-template.

1. Template Strand (Antisense Strand):

Function: The template strand serves as the blueprint for RNA synthesis during transcription.

Direction: It runs in the 3' to 5' direction, allowing the RNA polymerase to synthesize mRNA in the 5' to 3' direction.

Transcription: The sequence of nucleotides on the template strand is complementary to the RNA transcript produced.

Role in Transcription: Directly guides the sequence of the RNA molecule by providing the complementary bases (A pairs with U, T pairs with A, G pairs with C, and C pairs with G).

2. Non-Template Strand (Sense Strand, Coding Strand):

Function: The non-template strand does not directly participate in transcription but has the same nucleotide sequence as the RNA transcript (except that thymine (T) is replaced with uracil (U) in RNA).

Direction: It runs in the 5' to 3' direction.

Transcription: This strand is not used by RNA polymerase during the transcription process.

Role in Transcription: Its sequence is similar to the mRNA sequence that will be synthesized, providing a reference for the resultant mRNA's nucleotide sequence (except T is replaced with U).

59. Write role of Triglycerides in plants.

Energy Storage:

Long-Term Reserves: Triglycerides store energy densely in seeds and fruits, providing a crucial energy source during germination and early growth stages.

High Energy Density: They store about twice the energy per gram compared to carbohydrates, making them efficient for long-term energy storage.

Seed Germination and Growth:

Energy Source: During germination, triglycerides are broken down into fatty acids and glycerol, which are then converted into sugars to fuel the growing plant.

Support Development: The energy from triglycerides sustains seedlings until they can produce their own energy through photosynthesis.

Membrane Formation and Function:

Lipid Biosynthesis: Fatty acids from triglycerides are used to synthesize essential lipids for cellular membranes, critical for cell structure and function.

Structural Integrity: These lipids help maintain membrane integrity, ensuring proper cellular functions during growth.

Protection and Insulation:

Environmental Stress: Triglycerides provide a protective layer against environmental stress such as extreme temperatures and dehydration.

Temperature Regulation: They help insulate cells, aiding in temperature regulation and protecting cellular components.

Secondary Metabolism:

Signaling Molecules: Derivatives of fatty acids from triglycerides can act as signaling molecules in plant processes, including stress responses.

Defense Compounds: Some derivatives are involved in synthesizing defense compounds that protect plants from herbivores and pathogens.

60. What are Inhibitors and its types?

Inhibitors are substances that decrease the activity of enzymes, reducing the rate of biochemical reactions. Here are the main types of enzyme inhibitors:

Competitive Inhibitors: Bind to the active site of the enzyme, competing with the substrate. Increase Km, no change in Vmax.

Non-Competitive Inhibitors: Bind to an allosteric site, not the active site, reducing the enzyme's activity. No change in Km, decrease in Vmax.

Uncompetitive Inhibitors: Bind only to the enzyme-substrate complex, decreasing both Km and Vmax.

Mixed Inhibitors: Bind to either the enzyme or enzyme-substrate complex, affecting both Km and Vmax differently.

Irreversible Inhibitors: Form covalent bonds with the enzyme, permanently inactivating it. Decrease Vmax, no change in Km.

Allosteric Inhibitors: Bind to an allosteric site, inducing conformational changes that reduce enzyme activity, affecting both Km and Vmax variably.

61. What is small Km and Large Km?

In enzymology, "small Km" refers to a low Michaelis constant (Km), indicating high substrate affinity, while "large Km" indicates a high Michaelis constant, meaning lower substrate affinity.

62. Write short note on Immunoglobulins.

Immunoglobulins, also known as antibodies, are glycoprotein molecules produced by plasma cells in response to foreign antigens (antibodies). They play a crucial role in the immune system by recognizing and binding to specific antigens, marking them for destruction or neutralization by other immune cells. Structurally, immunoglobulins consist of two identical heavy chains and two identical light chains linked together, forming a Y-shaped molecule with antigen-binding sites at the tips. There are several classes of immunoglobulins (IgG, IgM, IgA, IgE, IgD), each with distinct functions and distributions within the body, contributing to various aspects of immune defense and regulation.

63. What is storage protein?

A storage protein is a type of protein that cells use to store amino acids for later use in metabolic processes, such as growth, development, or response to nutrient availability. Examples include ferritin, which stores iron, and casein, which stores amino acids in milk.

64. Explain Lineweaver Burk plot.

The Lineweaver-Burk plot is a graphical representation used in enzyme kinetics to analyze the Michaelis-Menten equation. It is constructed by plotting the reciprocal of the initial reaction rate ($1/V_0$) against the reciprocal of the substrate concentration ($1/[S]$). This plot transforms the hyperbolic Michaelis-Menten curve into a straight line, making it easier to determine key parameters such as the Michaelis constant (Km) and the maximum reaction rate (Vmax). The slope of the Lineweaver-Burk plot is equal to Km/Vmax, the y-intercept is 1/Vmax, and the x-intercept is -1/Km. This method provides a visual and quantitative approach to analyze enzyme kinetics and understand how enzymes interact with substrates.

65. Define enzyme. Write its classification and types.

An enzyme is a biological catalyst, typically a protein, that accelerates chemical reactions within cells by lowering the activation energy required for these reactions to occur.

Classification:

Enzymes are classified into several groups based on the reactions they catalyze:

1. Oxidoreductases: Catalyze oxidation-reduction reactions.
2. Transferases: Transfer functional groups between molecules.
3. Hydrolases: Catalyze hydrolysis reactions (breakdown of compounds by water).
4. Lyases: Catalyze addition or removal of groups to form double bonds.
5. Isomerases: Catalyze isomerization reactions (rearrangement of atoms within a molecule).
6. Ligases (synthetases): Catalyze joining of molecules using ATP.

Types:

Enzymes can also be categorized based on their substrate specificity and action:

1. Proteases: Catalyze the breakdown of proteins.
2. Lipases: Catalyze the breakdown of lipids.
3. Amylases: Catalyze the breakdown of carbohydrates.
4. Polymerases: Catalyze the synthesis of nucleic acids.

66. What are uses of Linolin?

Linalool is a versatile compound with several practical applications:

1. Fragrance: Linalool is commonly used in perfumes, cosmetics, and household products for its pleasant floral scent.

2. Flavoring: It is used as a flavoring agent in food and beverages due to its sweet, floral taste.

3. Medicinal: Linalool has potential medicinal properties, including anti-inflammatory and anti-anxiety effects, making it useful in aromatherapy and herbal medicine.

4. Industrial: It serves as a precursor in the synthesis of other compounds used in various industrial applications, such as in the production of vitamin E.

67. Explain long and small non-coding RNAs.

Non-coding RNAs (ncRNAs) are RNA molecules that do not encode proteins but play crucial roles in various cellular processes.

1. Small non-coding RNAs (sncRNAs): These are typically less than 200 nucleotides in length and include microRNAs (miRNAs) and small interfering RNAs (siRNAs). They regulate gene expression by binding to complementary sequences of messenger RNAs (mRNAs), leading to their degradation or inhibition of translation.

2. Long non-coding RNAs (lncRNAs): These are longer than 200 nucleotides and have diverse functions, including regulation of gene expression at transcriptional and post-transcriptional levels, chromatin remodeling, and acting as scaffolds for protein complexes. They contribute significantly to cellular processes and development, despite not encoding proteins themselves.

68. Name three pyrimidine bases.

Three pyrimidine bases are:

1. Cytosine (C)
2. Thymine (T)
3. Uracil (U)

69. Write steps of protein folding and its importance.

Steps of Protein Folding:

1. Primary Structure Formation: Sequence of amino acids is determined by mRNA translation.
2. Secondary Structure Formation: Folding into alpha helices or beta sheets via hydrogen bonds.
3. Tertiary Structure Formation: Further folding and interactions (hydrophobic, ionic, disulfide bonds) creating a 3D shape.
4. Quaternary Structure (if applicable): Assembly of multiple polypeptide subunits.

Importance:

Proper folding ensures functional proteins; misfolding can lead to diseases like Alzheimer's and Parkinson's.

70. Write composition of bile.

Bile is composed of:

1. Bile Salts: Primarily sodium glycocholate and sodium taurocholate, which aid in emulsification of fats.
2. Bilirubin: A waste product derived from the breakdown of heme in red blood cells.
3. Cholesterol: Present in small amounts.
4. Phospholipids: Particularly phosphatidylcholine, which aids in the solubilization of fats.
5. Water: Provides the medium for bile secretion and transport.
6. Electrolytes: Including sodium, potassium, calcium, and bicarbonate ions.

71. Differentiate between fat and oil.

Fat:

1. State at Room Temperature: Typically solid.
2. Source: Primarily from animal sources (e.g., butter, lard).
3. Composition: Generally higher in saturated fats.
4. Usage: Used in cooking, baking, and food preparation.

Oil:

1. State at Room Temperature: Typically liquid.
2. Source: Primarily from plant sources (e.g., olive oil, sunflower oil).
3. Composition: Often higher in unsaturated fats (monounsaturated or polyunsaturated).
4. Usage: Used in cooking, frying, dressings, and as a condiment.

72. What are types of lipoproteins?

There are several types of lipoproteins, each with distinct functions in lipid transport and metabolism:

1. Chylomicrons: Largest and least dense lipoproteins, transport dietary triglycerides from the intestines to the liver and peripheral tissues.

2. Very Low-Density Lipoproteins (VLDL): Produced by the liver, transport endogenous triglycerides to peripheral tissues.

3. Low-Density Lipoproteins (LDL): Mainly carry cholesterol from the liver to peripheral tissues, often referred to as "bad cholesterol" due to its association with cardiovascular diseases.

4. High-Density Lipoproteins (HDL): Synthesized in the liver and intestines, transport cholesterol from peripheral tissues back to the liver for excretion or recycling, known as "good cholesterol" due to its protective role against cardiovascular diseases.

73. Write functions of lipoxin.

Lipoxins are specialized pro-resolving mediators derived from arachidonic acid metabolism. Their functions include:

1. Anti-inflammatory Effects: Lipoxins inhibit neutrophil infiltration and activation, reducing inflammation at sites of injury or infection.

2. Resolution of Inflammation: They promote the resolution phase of inflammation by enhancing the clearance of inflammatory cells and debris.

3. Regulation of Immune Responses: Lipoxins help maintain immune homeostasis by modulating the activity of immune cells and cytokine production.

4. Tissue Repair: They support tissue repair and regeneration following inflammation by promoting the return to normal tissue structure and function.

74. Define catalytic reaction of Xanthine.

A catalytic reaction involving xanthine typically refers to its role as a substrate in enzymatic reactions catalyzed by xanthine oxidoreductase (XOR). Xanthine undergoes oxidation by XOR to form uric acid, hydrogen peroxide, and superoxide anion radicals. This reaction is part of purine metabolism in humans and other organisms, where xanthine serves as an intermediate in the conversion of hypoxanthine to uric acid. The catalytic action of XOR is crucial in regulating uric acid levels in the body and has implications in diseases such as gout and hyperuricemia.

75. Write note on importance of carbohydrates in biomedical field.

Carbohydrates play crucial roles in the biomedical field due to their diverse functions in biological systems:

1. Energy Source: Carbohydrates, primarily glucose, serve as the main energy source for cellular processes through glycolysis and oxidative phosphorylation.

2. Structural Components: Carbohydrates are integral to the structure of cells and tissues, forming glycoproteins, glycolipids, and proteoglycans that are essential for cell membranes and extracellular matrix integrity.

3. Cell-Cell Recognition: Carbohydrates on cell surfaces act as recognition markers, facilitating immune responses, cell adhesion, and communication between cells.

4. Storage and Transport: Carbohydrates like glycogen in animals and starch in plants serve as storage forms of glucose, providing a readily available energy reserve. Additionally, blood group antigens (ABO blood group system) are carbohydrate-based markers crucial in blood transfusions and tissue transplantation.

5. Disease Markers: Changes in carbohydrate structures on glycoproteins and glycolipids are associated with various diseases, such as cancer and congenital disorders, making them important biomarkers for diagnostics and therapeutic targeting.

76. How phosphodiester bond is formed?

Phosphodiester bonds are formed through a condensation reaction between the hydroxyl group (-OH) of one nucleotide's 3' carbon and the phosphate group (PO_4) attached to the 5' carbon of another nucleotide. Here's how it happens:

1. Formation of Phosphodiester Linkage:

The phosphate group of a nucleotide (with its attached base) is activated by the removal of two phosphate groups, leaving a phosphate ion (PO_4^{3-}). The 3' hydroxyl group of another nucleotide attacks the phosphate ion. This nucleophilic attack results in the formation of a covalent bond between the phosphate group and the 3' carbon of the nucleotide, forming a phosphodiester bond.

2. Release of Water Molecule:

The condensation reaction releases a water molecule (H_2O) as a byproduct.

3. Polymerization:

This process repeats sequentially as nucleotides join together, forming a linear chain (strand) of nucleotides connected by phosphodiester bonds.

77. Define starch and its structure.

Starch is a polysaccharide carbohydrate composed of glucose units linked together by glycosidic bonds. It serves as a major energy storage molecule in plants, similar to how glycogen functions in animals.

Structure of Starch:

1. Amylose: A linear polymer of α-D-glucose units connected by α (1→4) glycosidic bonds. Amylose typically makes up about 20-30% of starch molecules. It forms a helical structure due to its α (1→4) linkages.

2. Amylopectin: A branched polymer of α-D-glucose units linked by both α (1→4) and α (1→6) glycosidic bonds. Amylopectin constitutes the majority of starch molecules (about 70-80%). Its branched structure allows for more efficient packing and storage of glucose.

78. What are examples of unsaturated fatty acids?

Examples of unsaturated fatty acids include:

1. Monounsaturated Fatty Acids (MUFAs):

- Oleic acid (found in olive oil, avocados, and nuts)
- Palmitoleic acid (found in macadamia nuts and palm oil)

2. Polyunsaturated Fatty Acids (PUFAs):

- Omega-3 fatty acids (e.g., α-linolenic acid, EPA, DHA; found in fatty fish like salmon, flaxseeds, and walnuts)
- Omega-6 fatty acids (e.g., linoleic acid, arachidonic acid; found in vegetable oils like corn oil and soybean oil)

79. What is Histone? Write its classes.

Histones are proteins that package and organize DNA into structural units called nucleosomes, which are fundamental components of chromatin in eukaryotic cells. They play crucial roles in regulating gene expression and maintaining the stability of the genome. There are two classes:

1. Core Histones:

- H2A
- H2B
- H3
- H4

These histones form an octamer core around which DNA is wrapped to form the nucleosome structure. They are highly conserved across species and are involved in the structural organization of chromatin.

2. Linker Histones:

- H1 (also known as H5 in some organisms)

Linker histones bind to the DNA between nucleosomes, helping to stabilize higher-order chromatin structures and regulating access to the DNA during transcription and replication.

80. What is the effect of abnormal sequence of amino acids?

An abnormal sequence of amino acids in a protein can have several effects, depending on the specific location and nature of the alteration:

1. Loss of Function: The protein may lose its normal function due to disruption of critical structural elements or active sites necessary for its activity. This can lead to deficiencies in cellular processes that rely on the normal function of the protein.

2. Gain of Function: In some cases, an abnormal sequence may confer new functions or alter the protein's interactions with other molecules, leading to unintended consequences such as abnormal signaling pathways or cellular responses.

3. Misfolding and Aggregation: Incorrect amino acid sequences can result in protein misfolding, where the protein adopts an abnormal three-dimensional structure. Misfolded proteins may aggregate and form insoluble clumps, which can be toxic to cells and contribute to the development of neurodegenerative diseases like Alzheimer's and Parkinson's.

4. Instability: Abnormal amino acid sequences can destabilize the protein structure, making it more prone to degradation by cellular quality control mechanisms or leading to premature degradation before it can fulfill its normal function.

5. Disease Associations: Mutations that result in abnormal amino acid sequences are often associated with genetic diseases known as "proteinopathies," where defective proteins contribute to disease pathogenesis. Examples include cystic fibrosis (CFTR protein), sickle cell disease (hemoglobin), and various forms of cancer driven by mutated proteins.

81. Explain Ligand.

A ligand is a molecule or ion that binds specifically to a receptor site on a protein, typically a larger molecule. The binding of a ligand to its receptor usually results in a specific biological response. Here are some key points about ligands:

1. Types of Ligands:

Endogenous Ligands: Naturally occurring molecules in the body that bind to receptors, such as neurotransmitters, hormones, and metabolites.

Exogenous Ligands: Molecules from external sources that can bind to receptors, including drugs, toxins, and environmental chemicals.

82. Write physical properties of Cis.

In biochemistry, "cis" and "trans" configurations often refer to the spatial arrangement around double bonds in fatty acids or the orientation of functional groups in biomolecules. Here are the physical properties associated with cis isomers from a biochemical perspective:

1. Spatial Arrangement: Cis isomers have similar atoms or groups on the same side of a double bond or ring structure, leading to a bent or kinked molecular shape.

2. Melting Point: Cis isomers often have lower melting points compared to their trans counterparts. This is due to the bent shape, which prevents close packing and results in weaker intermolecular forces.

3. Biological Activity: The cis configuration can influence biological activity by affecting interactions with enzymes, receptors, or other biomolecules. For example, cis unsaturated fatty acids are more likely to participate in biological processes such as membrane fluidity regulation and signaling pathways.

4. Chemical Reactivity: Cis isomers may exhibit different chemical reactivity compared to trans isomers due to their distinct molecular shapes and electronic distributions. This can impact their stability and susceptibility to oxidation or other chemical modifications in biological systems.

83.