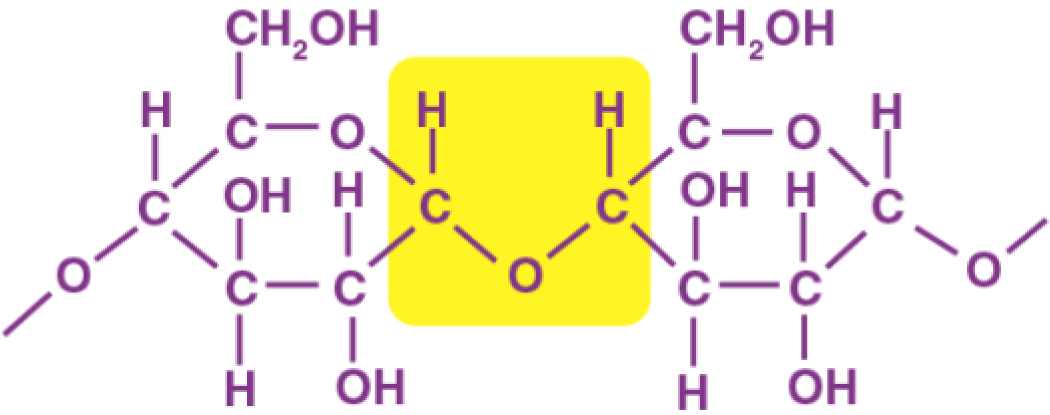
UNIT – III NATURAL PRODUCTS

Carbohydrates-polysaccharides-structure of starch, and cellulose, configuration of carbohydrates-photosynthesis

Carbohydrates:

1. **Definition and Classification:**
    - Carbohydrates are organic compounds composed of carbon, hydrogen, and oxygen in the ratio of 1:2:1.
    - Classified into monosaccharides (simple sugars), disaccharides (two monosaccharide units), and polysaccharides (long chains of monosaccharide units).
2. **Monosaccharides:**
    - Simplest carbohydrates, with the general formula $(CH_2O)n$.
    - Examples include glucose, fructose, and galactose.
    - Serve as energy sources and building blocks for larger carbohydrates.
3. **Disaccharides:**
    - Formed by the condensation reaction between two monosaccharide molecules, resulting in the formation of a glycosidic bond.
    - Common disaccharides include sucrose (glucose + fructose), lactose (glucose + galactose), and maltose (glucose + glucose).
4. **Polysaccharides:**
    - Complex carbohydrates composed of long chains of monosaccharide units.
    - Serve as energy storage molecules (e.g., starch) and structural components (e.g., cellulose) in living organisms.

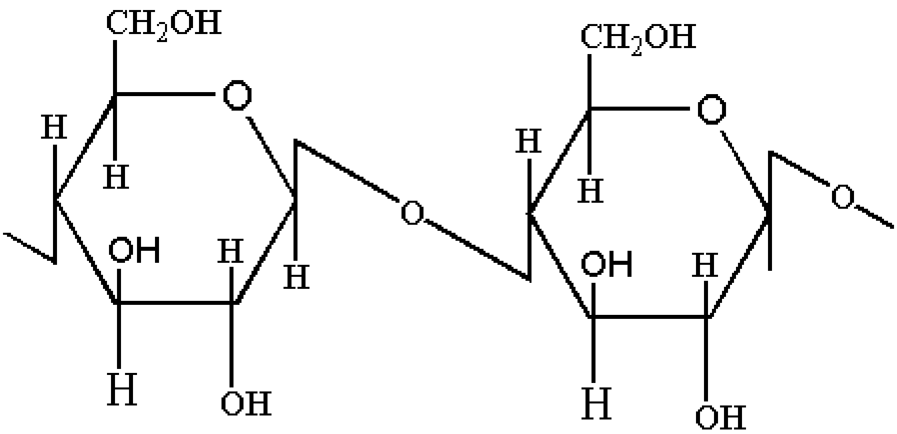
Structure of Starch:



Simple starch

1. **Composition:**
   - Starch is a polysaccharide composed of glucose monomers linked by glycosidic bonds.
   - Consists of two main components: amylose and amylopectin.
2. **Amylose:**
   - Linear polymer of α-D-glucose units linked by α(1→4) glycosidic bonds.
   - Forms a helical structure due to intramolecular hydrogen bonding.
   - Provides compact storage of glucose in plants.
3. **Amylopectin:**
   - Branched polymer of α-D-glucose units linked by α(1→4) and α(1→6) glycosidic bonds.
   - Contains both linear and branched regions, allowing for rapid enzymatic degradation.
   - Acts as a readily available energy source in plants.

Structure of Cellulose:



Cellulose

1. **Composition:**
   - Cellulose is a linear polysaccharide composed of β-D-glucose units linked by β(1→4) glycosidic bonds.
   - Forms long, unbranched chains stabilized by intermolecular hydrogen bonding.
2. **Microfibril Structure:**
   - Cellulose molecules associate to form microfibrils, which further aggregate to form cellulose fibers.
   - Provides structural support and rigidity to plant cell walls.
3. **Hydrogen Bonding:**
   - Extensive hydrogen bonding between adjacent cellulose chains contributes to the high tensile strength and insolubility of cellulose.
   - Renders cellulose resistant to enzymatic degradation by most organisms, except for cellulose-degrading bacteria and fungi.

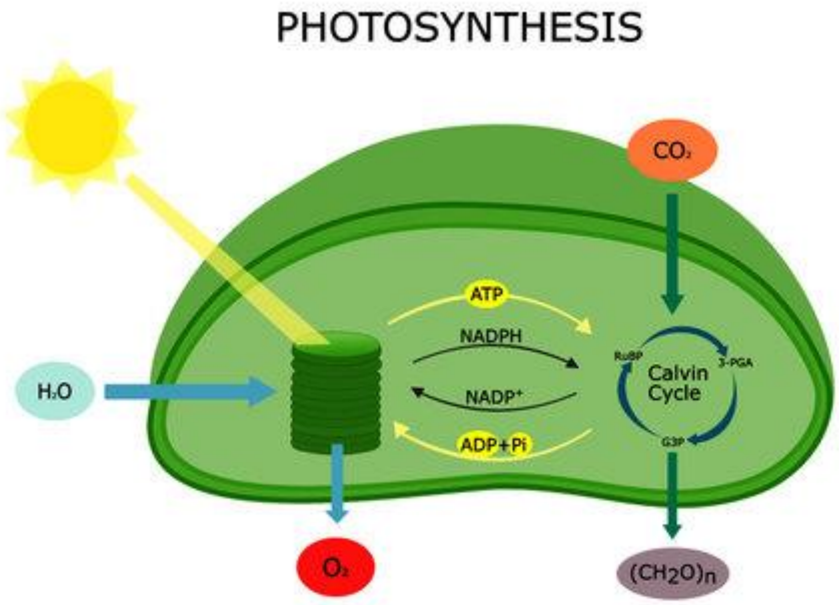
Configuration of Carbohydrates:

1. **Chirality:**
   - Most monosaccharides are chiral molecules with multiple asymmetric carbon atoms.
   - Exist as enantiomers (mirror-image isomers) and diastereomers (non-mirror-image isomers).
2. **Fischer and Haworth Projections:**
   - Fischer projections are used to represent the 3D structure of carbohydrates in a 2D format.
   - Haworth projections depict the cyclic structure of monosaccharides, particularly in the case of pyranose and furanose rings.

Photosynthesis:

1. **Process Overview:**
   - Photosynthesis is the biochemical process by which green plants, algae, and some bacteria convert light energy into chemical energy in the form of glucose.

- Occurs in chloroplasts, primarily in the mesophyll cells of plant leaves.

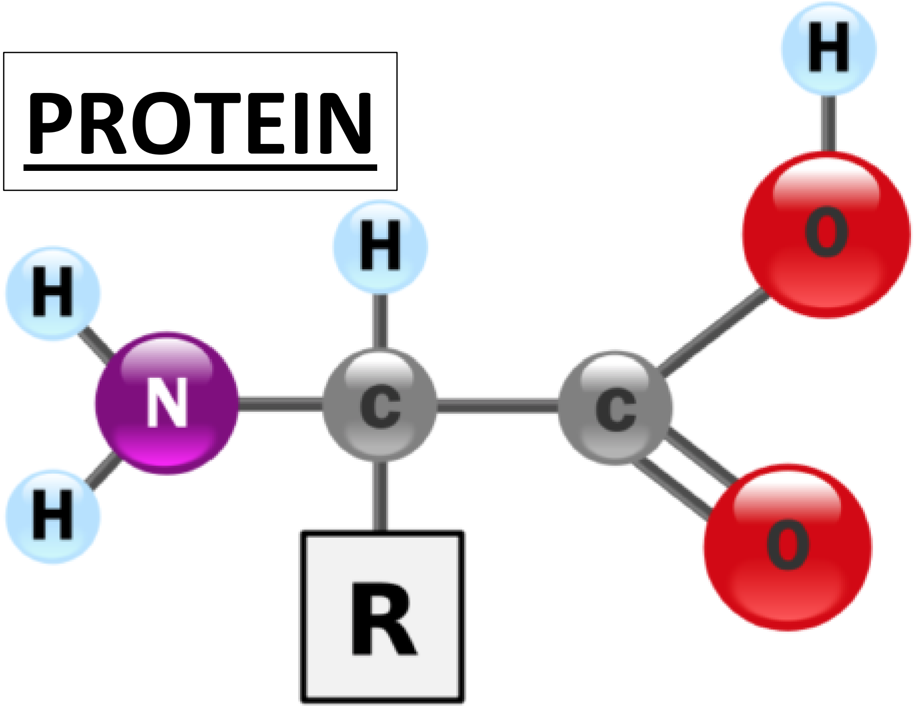


2. **Light Reactions:**
    - Light energy is absorbed by chlorophyll molecules in the thylakoid membranes of chloroplasts.
    - Energy is used to drive electron transport chains, generating ATP and reducing equivalents (NADPH) through photophosphorylation.
3. **Carbon Fixation:**
    - In the Calvin cycle (dark reactions), carbon dioxide is fixed and reduced to form glucose.
    - ATP and NADPH generated in the light reactions are utilized to convert carbon dioxide into glucose through a series of enzymatic reactions.
4. **Overall Equation:**
    - $6CO_2 + 6H_2O$ + light energy $\rightarrow C_6H_{12}O_6 + 6O_2$
    - Carbon dioxide and water are converted into glucose and oxygen in the presence of light energy, with oxygen released as a byproduct.

Proteins& peptides:

Naturally Occurring Amino Acids:

PROTEIN



1. Definition:

    - Amino acids are organic compounds that serve as the building blocks of proteins.
    - They contain an amino group (-NH2) and a carboxyl group (-COOH) attached to a central carbon atom, along with a side chain (R group) that varies among different amino acids.

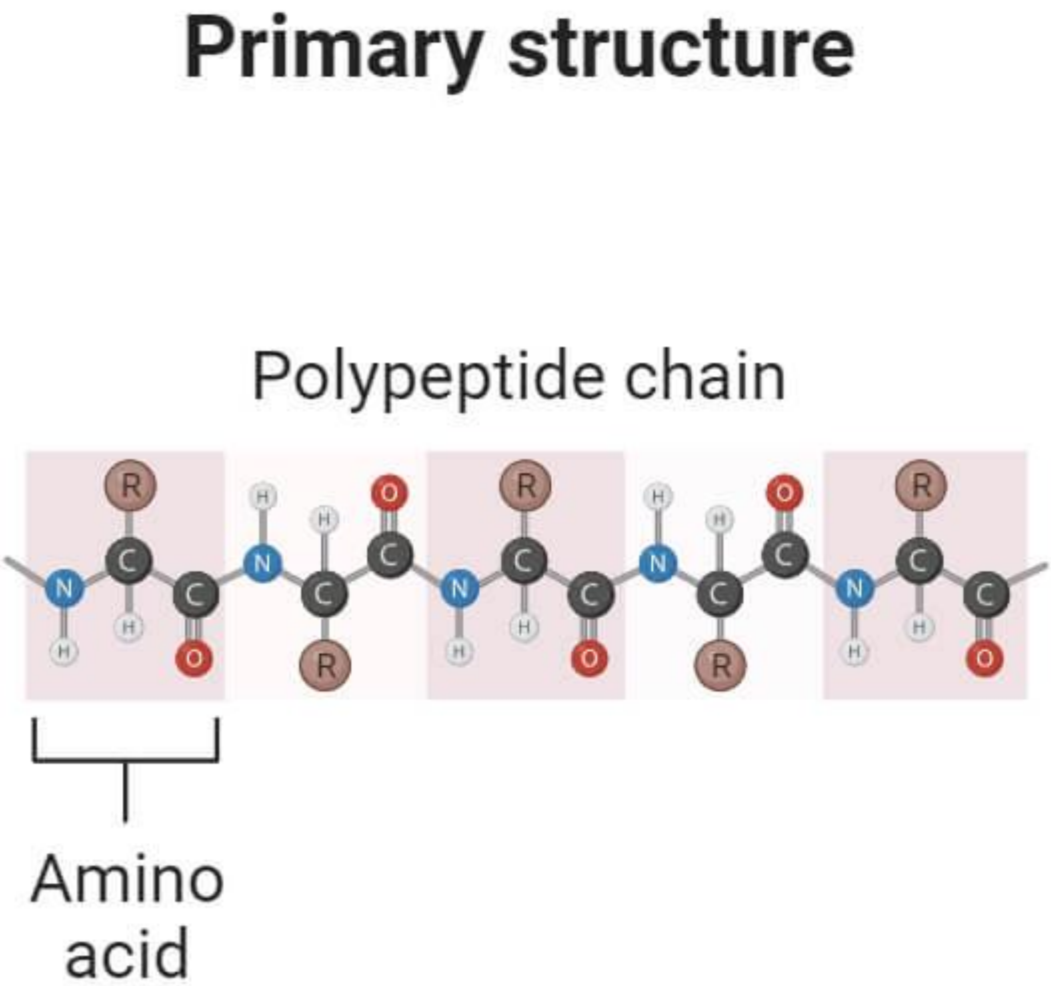
2. Classification:

    - Naturally occurring amino acids can be classified based on the properties of their side chains:
        - Non-polar (hydrophobic) amino acids.
        - Polar (hydrophilic) amino acids.
        - Acidic amino acids.
        - Basic amino acids.

3. Non-polar (Hydrophobic) Amino Acids:

    - Glycine (Gly, G)
    - Alanine (Ala, A)
    - Valine (Val, V)
    - Leucine (Leu, L)
    - Isoleucine (Ile, I)
    - Methionine (Met, M)
    - Phenylalanine (Phe, F)
    - Tryptophan (Trp, W)
    - Proline (Pro, P)

4. Polar (Hydrophilic) Amino Acids:
    - Serine (Ser, S)
    - Threonine (Thr, T)
    - Cysteine (Cys, C)
    - Tyrosine (Tyr, Y)
    - Asparagine (Asn, N)
    - Glutamine (Gln, Q)
5. Acidic Amino Acids:
    - Aspartic Acid (Asp, D)
    - Glutamic Acid (Glu, E)
6. Basic Amino Acids:
    - Lysine (Lys, K)
    - Arginine (Arg, R)
    - Histidine (His, H)
7. Special Amino Acids:
    - Cysteine (Cys, C): Contains a thiol group (-SH) in its side chain, forming disulfide bonds important for protein structure.
    - Proline (Pro, P): Contains a cyclic side chain, which introduces rigidity into protein structures.
8. Essential and Non-essential Amino Acids:
    - Essential amino acids cannot be synthesized by the body and must be obtained from the diet.
    - Non-essential amino acids can be synthesized by the body.



their classifications:

1. **Non-polar (Hydrophobic) Amino Acids**:
   - Characterized by side chains that are primarily composed of hydrocarbons.
   - Tend to avoid interaction with water molecules.
   - Commonly found in the interior of proteins where they contribute to protein folding and stability.
   - Include glycine, alanine, valine, leucine, isoleucine, methionine, phenylalanine, tryptophan, and proline.
2. **Polar (Hydrophilic) Amino Acids**:
   - Have side chains that contain functional groups capable of forming hydrogen bonds with water molecules.
   - Often found on the surface of proteins, where they interact with water and other polar molecules.
   - Include serine, threonine, cysteine, tyrosine, asparagine, and glutamine.
3. **Acidic Amino Acids**:

- Possess side chains that can ionize to release a proton, resulting in a negative charge at physiological pH.
- Can participate in electrostatic interactions with positively charged molecules or ions.
- Include aspartic acid and glutamic acid.

4. **Basic Amino Acids**:
    - Contain side chains that can accept protons, resulting in a positive charge at physiological pH.
    - Often involved in forming salt bridges or ion pairs with negatively charged molecules or ions.
    - Include lysine, arginine, and histidine.
5. **Special Amino Acids**:
    - Have unique properties or structures that set them apart from other amino acids.
    - Examples include cysteine, which forms disulfide bonds important for protein structure, and proline, which introduces rigidity into protein structures with its cyclic side chain.

acid-base properties and their importance:

Acid-Base Properties:

1. **Acidic Amino Acids**:
    - Aspartic acid (Asp) and glutamic acid (Glu) are examples.
    - They possess a carboxyl group (-COOH) in their side chains.
    - At physiological pH, these groups can ionize, releasing a proton (H+), and becoming negatively charged (-COO-).
    - As a result, acidic amino acids contribute to the overall negative charge of proteins.
2. **Basic Amino Acids**:
    - Lysine (Lys), arginine (Arg), and histidine (His) exhibit basic properties.
    - They contain amino groups (-NH2) in their side chains.
    - At physiological pH, these groups can accept protons, becoming positively charged (+NH3+).
    - Basic amino acids contribute to the overall positive charge of proteins.

Importance:

1. **Maintaining pH Balance**:
    - Amino acids play a crucial role in maintaining the pH balance within biological systems.
    - Acidic and basic amino acids contribute to the buffering capacity of proteins, helping to stabilize intracellular and extracellular pH levels.
2. **Protein Structure and Stability**:
    - Acidic and basic amino acids participate in the formation of salt bridges or ion pairs within protein structures.

- These interactions contribute to the stability and proper folding of proteins, influencing their overall structure and function.

3. **Enzyme Catalysis**:

    - The acid-base properties of amino acids are essential for the catalytic activity of enzymes.
    - They can serve as proton donors or acceptors in enzyme-substrate interactions, facilitating biochemical reactions.

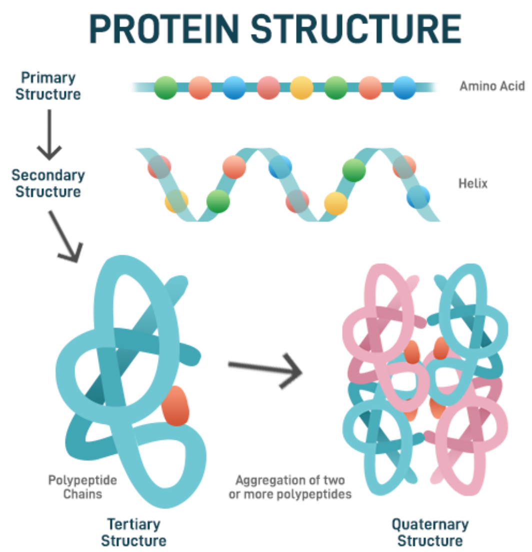
4. **Protein-Protein Interactions**:

    - Acidic and basic amino acids are involved in protein-protein interactions.
    - Electrostatic interactions between oppositely charged amino acids mediate binding between proteins, influencing various cellular processes such as signal transduction and molecular recognition.

5. **Binding of Ligands**:

    - Acidic and basic amino acids often play a role in binding ligands or cofactors to proteins.
    - Their ability to form specific interactions with ligands contributes to the functional diversity of proteins, including receptors, transporters, and enzymes.

primary, secondary, tertiary and quaternary structures of proteins:



PRIMARY STRUCTURE

1. **Definition**:

    - The primary structure of a protein refers to the linear sequence of amino acids in its polypeptide chain.
    - It is determined by the order of amino acids encoded in the gene that specifies the protein.

2. **Key Features**:
   - Sequence of amino acids linked by peptide bonds.
   - Contains information critical for determining the folding and function of the protein.
   - Primary structure is unique to each protein and is fundamental to its biological activity.

Secondary Structure:

1. **Definition**:
   - Secondary structure refers to the local spatial arrangement of the polypeptide backbone.
   - It is stabilized by hydrogen bonding between backbone atoms.
2. **Common Secondary Structures**:
   - **Alpha-helix**: Formed by a right-handed coil stabilized by intramolecular hydrogen bonds between amino and carbonyl groups of nearby residues.
   - **Beta-sheet**: Consists of strands connected by hydrogen bonds between backbone atoms, forming either parallel or antiparallel arrangements.
3. **Importance**:
   - Secondary structures contribute to the overall folding and stability of proteins.
   - They often occur in specific regions of proteins, such as alpha-helices in membrane-spanning regions or beta-sheets in protein cores.

Tertiary Structure:

1. **Definition**:
   - Tertiary structure refers to the three-dimensional conformation of the entire polypeptide chain.
   - It is stabilized by interactions between amino acid side chains (R groups), including hydrogen bonds, hydrophobic interactions, disulfide bonds, and electrostatic interactions.
2. **Key Features**:
   - Gives rise to the unique overall shape of the protein.
   - Determines the functional properties of the protein, including its enzymatic activity, ligand binding, and interaction with other molecules.
3. **Folding Motifs**:
   - Tertiary structure may include specific folding motifs, such as helix-turn-helix, beta-alpha-beta, or zinc finger motifs, which contribute to the protein's function.

Quaternary Structure:

1. **Definition**:
   - Quaternary structure refers to the arrangement of multiple polypeptide subunits in a protein complex.
   - It is stabilized by the same types of interactions as tertiary structure.
2. **Examples**:

- Proteins with quaternary structure may consist of two or more identical or different polypeptide chains called subunits.
- Examples include hemoglobin (composed of four subunits), DNA polymerase (composed of multiple subunits), and antibodies (composed of two heavy and two light chains).

3. **Importance**:
    - Quaternary structure is crucial for the function and regulation of many proteins.
    - It allows for cooperativity, where changes in one subunit affect the activity of other subunits, as seen in allosteric enzymes and multisubunit receptors.

Protection of N-terminal and C-terminal groups of proteins:

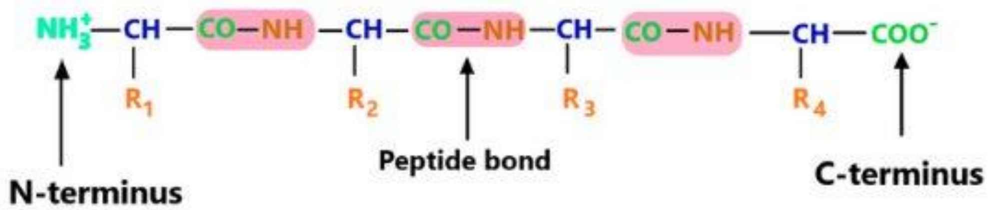


FIG: N-terminus and C-terminus of polypeptide chain

Protection of N-terminal Group:

1. **Acetylation**:
    - Addition of an acetyl group (-COCH3) to the N-terminal amino acid.
    - Protects the N-terminus from degradation by proteases.
    - Used in peptide synthesis and protein purification to prevent unwanted cleavage.
2. **Blocking Groups**:

- Chemical modification of the N-terminal amino group with protecting groups such as acetyl (Ac), formyl (For), or tert-butoxycarbonyl (Boc).
- These groups prevent unwanted reactions or interactions at the N-terminus during chemical synthesis or modification.

3. **Chemical Modification**:
    - Reaction of the N-terminal amino group with specific reagents to mask its reactivity.
    - Examples include carbamylation, sulfonation, or amidation, which alter the chemical properties of the N-terminus.

Protection of C-terminal Group:

1. **Methylation**:
    - Addition of a methyl group (-CH3) to the C-terminal carboxyl group.
    - Offers protection against enzymatic degradation and enhances stability.
    - Commonly used in peptide synthesis and protein modification.
2. **Amidation**:
    - Conversion of the C-terminal carboxyl group into an amide (-CONH2).
    - Provides protection against enzymatic cleavage by carboxypeptidases.
    - Utilized in peptide synthesis to stabilize the C-terminus and enhance peptide stability.
3. **Blocking Groups**:
    - Chemical modification of the C-terminal carboxyl group with protecting groups such as methyl (Me), benzyl (Bzl), or tert-butyl (tBu).
    - These groups shield the C-terminus from unwanted reactions or cleavage during chemical synthesis or modification.
4. **Chemical Modification**:
    - Reaction of the C-terminal carboxyl group with specific reagents to modify its chemical properties.
    - Examples include esterification, amidation, or alkylation, which alter the reactivity or stability of the C-terminus.

Importance:

1. **Prevention of Degradation**:
    - Protecting the N- and C-termini of proteins and peptides helps prevent enzymatic degradation by proteases.
    - This is crucial for maintaining the integrity and stability of proteins during purification, storage, and analysis.
2. **Facilitation of Chemical Synthesis**:
    - Chemical modification and protection of the N- and C-termini facilitate peptide and protein synthesis by controlling reactivity and preventing unwanted side reactions.
3. **Enhanced Stability**:

- Methylation, acetylation, amidation, and other protective strategies increase the stability of proteins and peptides, particularly in harsh chemical or biological environments.

4. **Controlled Modification**:

   - Protection of N- and C-terminal groups allows for controlled modification of proteins and peptides, enabling the introduction of specific functional groups or labels at desired locations.

Merifield's solid state peptide synthesis:

Merifield's solid-phase peptide synthesis (SPPS) revolutionized the production of peptides and small proteins. Here's a breakdown of Merifield's SPPS in points:

1. **Solid-Phase Synthesis Principle**:

   - Merifield's SPPS involves the stepwise assembly of peptides on a solid support.
   - The N-terminal amino acid is covalently attached to an insoluble resin, serving as the starting point for peptide elongation.

2. **Protecting Group Strategy**:

   - Amino acid side chains and functional groups are protected by removable protecting groups to ensure selective reactions during synthesis.
   - Common protecting groups include Boc (tert-butyloxycarbonyl) for amino groups and tBu (tert-butyl) for hydroxyl groups.

3. **Coupling Reaction**:

   - The amino acid monomer, with its N-terminus protected, is coupled to the growing peptide chain on the solid support.
   - Activation of the carboxyl group of the incoming amino acid is typically achieved using coupling reagents like DIC (diisopropylcarbodiimide) or HBTU (2-(1H-benzotriazol-1-yl)-1,1,3,3-tetramethyluronium hexafluorophosphate).

4. **Deprotection**:

   - After each coupling step, the N-terminal protecting group is removed to expose the amino group for the next coupling reaction.
   - Deprotection is often achieved using mild acidic conditions, such as treatment with trifluoroacetic acid (TFA), which cleaves the Boc protecting group.

5. **Repetitive Cycle**:

   - The process of coupling, deprotection, and washing is repeated iteratively for each amino acid added to the growing peptide chain.
   - Each coupling cycle adds one amino acid residue to the nascent peptide chain.

6. **Cleavage and Deprotection**:

   - Once the desired peptide sequence is assembled on the solid support, the peptide is cleaved from the resin and deprotected simultaneously.
   - This is typically achieved by treatment with a strong acid, such as a mixture of TFA and scavengers like triisopropylsilane (TIS) or thioanisole.

7. **Purification and Analysis**:
    - After cleavage, the crude peptide is typically purified by techniques such as chromatography, often using reversed-phase HPLC.
    - The purity and identity of the synthesized peptide are confirmed using analytical techniques like mass spectrometry and amino acid analysis.
8. **Advantages**:
    - Merifield's SPPS allows for the rapid and efficient synthesis of peptides and small proteins with high purity and yield.
    - It enables the synthesis of peptides with complex sequences and modifications.
    - Solid-phase synthesis minimizes the formation of unwanted side products and simplifies purification compared to solution-phase synthesis.
9. **Applications**:
    - Merifield's SPPS has wide-ranging applications in peptide chemistry, drug discovery, vaccine development, and biochemical research.
    - It is used for the synthesis of peptide hormones, enzyme substrates, receptor ligands, and therapeutic peptides.

Nucleic acids:

chemistry of nucleic acids:

Chemistry of Nucleic Acids:

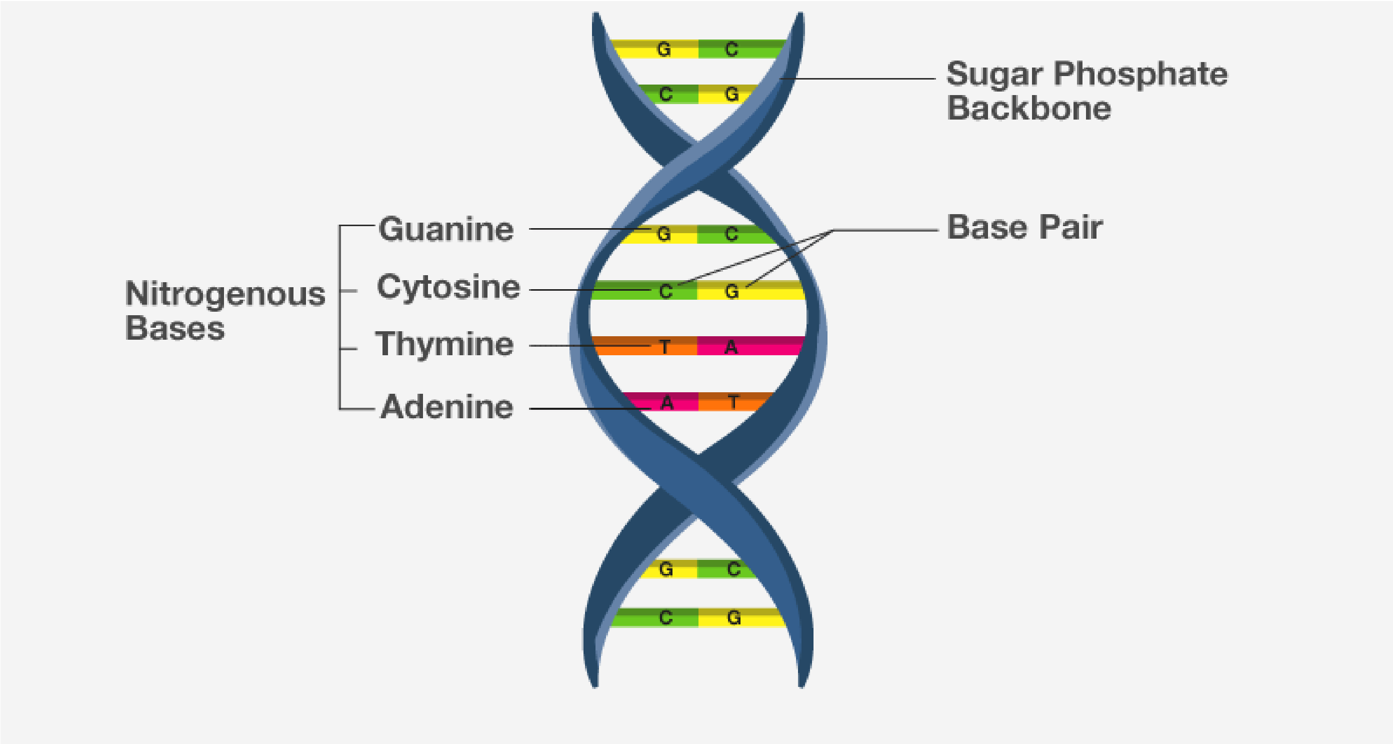
1. **Definition**:
    - Nucleic acids are biological macromolecules essential for the storage and transmission of genetic information.
    - They include deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).
2. **Composition**:
    - Nucleic acids are composed of nucleotides, which consist of three components:
        - Nitrogenous base: Purines (adenine and guanine) or pyrimidines (cytosine, thymine in DNA, and uracil in RNA).
        - Pentose sugar: Deoxyribose in DNA and ribose in RNA.
        - Phosphate group: Phosphoric acid linked to the sugar.
3. **Structural Features**:
    - DNA forms a double helix structure composed of two antiparallel strands.
    - RNA usually exists as a single-stranded molecule but can form secondary structures like hairpins and loops due to base pairing.
4. **Base Pairing**:

- In DNA, adenine (A) pairs with thymine (T) through two hydrogen bonds, while guanine (G) pairs with cytosine (C) through three hydrogen bonds.
- In RNA, adenine (A) pairs with uracil (U) through two hydrogen bonds.

5. **Backbone Structure**:
   - The backbone of nucleic acids is formed by alternating sugar-phosphate units.
   - Phosphate groups provide negative charge, contributing to the overall negative charge of the molecule.
6. **DNA Replication**:
   - DNA replication is the process by which DNA makes an exact copy of itself during cell division.
   - It involves unwinding of the double helix, separation of the two strands, and synthesis of new complementary strands using the existing strands as templates.
7. **Transcription**:
   - Transcription is the process by which RNA is synthesized from a DNA template.
   - RNA polymerase catalyzes the formation of RNA using one of the DNA strands as a template.
   - In eukaryotes, transcription occurs in the nucleus, while in prokaryotes, it occurs in the cytoplasm.
8. **Translation**:
   - Translation is the process by which proteins are synthesized using the information encoded in mRNA.
   - It occurs in the ribosomes, where tRNA molecules deliver amino acids based on the codons present in the mRNA.

Nucleic Acids: Structure of DNA, Properties, Biological Implications, Replication of DNA, Structure of RNA

Structure of DNA:



1. **Double Helix**:
   - DNA (Deoxyribonucleic Acid) is a double-stranded helical molecule.
   - The two strands are antiparallel, meaning they run in opposite directions.
   - The backbone of the DNA molecule is composed of sugar-phosphate groups, while the bases project inward and form hydrogen bonds between complementary base pairs (A-T and G-C).
2. **Base Pairing**:
   - Adenine (A) forms two hydrogen bonds with thymine (T), while guanine (G) forms three hydrogen bonds with cytosine (C).
   - This complementary base pairing allows DNA to replicate faithfully and ensures genetic stability.
3. **Major and Minor Grooves**:
   - The helical structure of DNA creates major and minor grooves along the length of the molecule.
   - These grooves provide binding sites for proteins involved in DNA regulation, replication, and repair.
4. **Supercoiling**:
   - DNA can adopt supercoiled structures, where the double helix is further twisted or coiled upon itself.
   - Supercoiling plays a crucial role in DNA packaging within the cell and regulates gene expression.

Properties of DNA:

1. **Genetic Information Storage**:
   - DNA carries the genetic information necessary for the development, growth, and functioning of all living organisms.
   - The sequence of nucleotide bases encodes the genetic instructions that determine an organism's traits.
2. **Chemical Stability**:

- DNA is chemically stable due to the covalent bonds between sugar and phosphate groups in the backbone and the hydrogen bonds between complementary base pairs.
- This stability ensures the preservation of genetic information over generations.

3. **Mutation and Variation**:
    - DNA is subject to mutations, which are changes in the nucleotide sequence.
    - Mutations can lead to genetic variation within populations and play a role in evolution, disease development, and adaptation to environmental changes.
4. **Replication and Transmission**:
    - DNA replication is the process by which DNA is copied to produce identical daughter molecules.
    - This ensures the transmission of genetic information from one generation to the next during cell division.

Biological Implications of DNA:

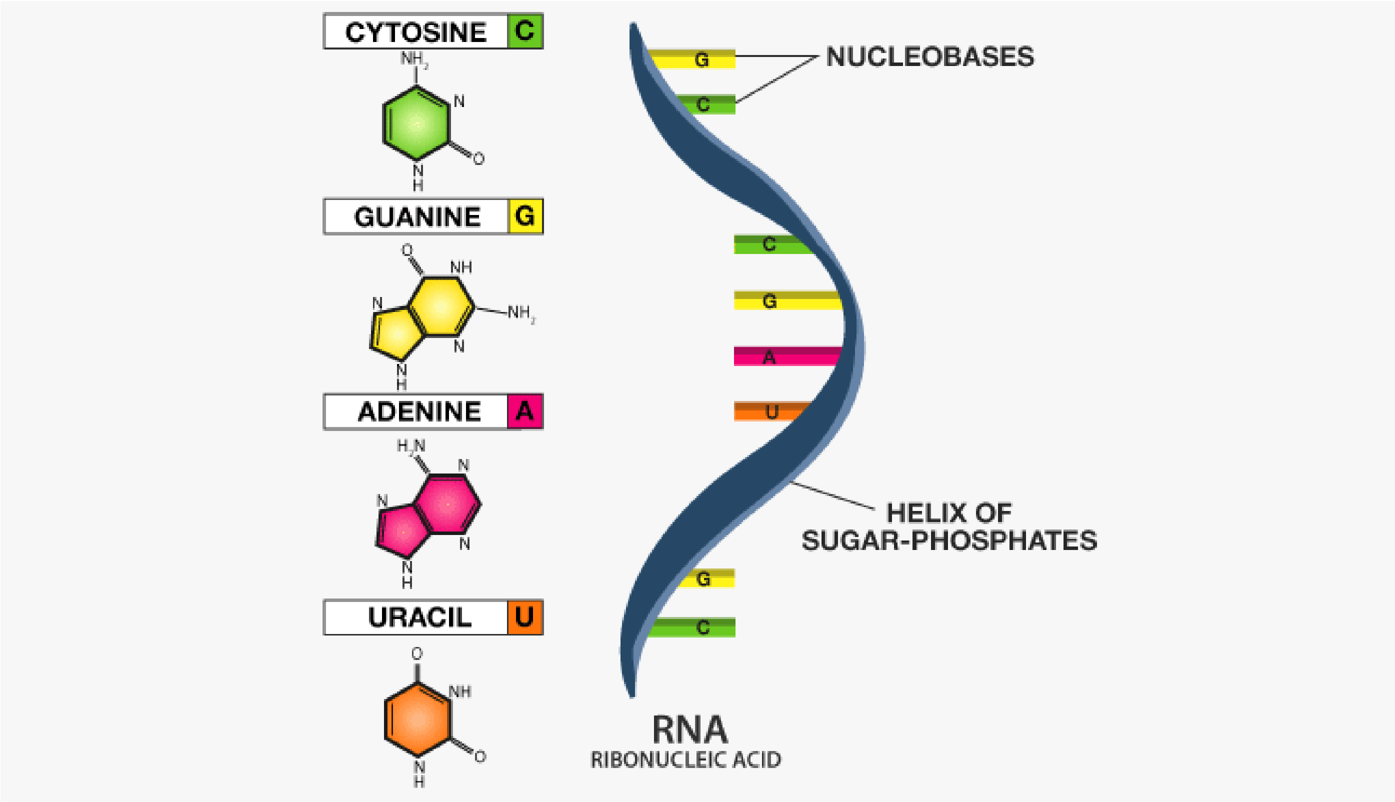
1. **Gene Expression**:
    - DNA serves as a template for the synthesis of RNA molecules, which in turn directs the synthesis of proteins through the process of translation.
    - Gene expression is regulated at multiple levels, including transcriptional and post-transcriptional mechanisms.
2. **Inheritance and Genetics**:
    - DNA is the hereditary material passed from parent to offspring.
    - Genetic variations and mutations in DNA contribute to inherited traits and genetic disorders.
3. **Evolutionary Conservation**:
    - Many aspects of DNA structure, function, and regulation are conserved across diverse species, reflecting shared evolutionary history.
    - Comparative genomics and molecular biology studies provide insights into the evolutionary relationships between organisms.

Replication of DNA:

1. **Semiconservative Replication**:
    - DNA replication follows a semiconservative model, where each parental DNA strand serves as a template for the synthesis of a new complementary strand.
    - The resulting DNA molecules consist of one parental strand and one newly synthesized strand.
2. **Enzymatic Machinery**:
    - DNA replication is catalyzed by a complex of enzymes, including DNA polymerases, helicases, primases, and DNA ligases.
    - These enzymes coordinate the unwinding of the DNA double helix, synthesis of new DNA strands, and sealing of DNA fragments.
3. **Origin of Replication**:

- DNA replication initiates at specific sites called origins of replication, where the DNA strands are unwound to form replication forks.
- Replication proceeds bidirectionally from each origin, leading to the synthesis of two daughter DNA molecules.

Structure of RNA:

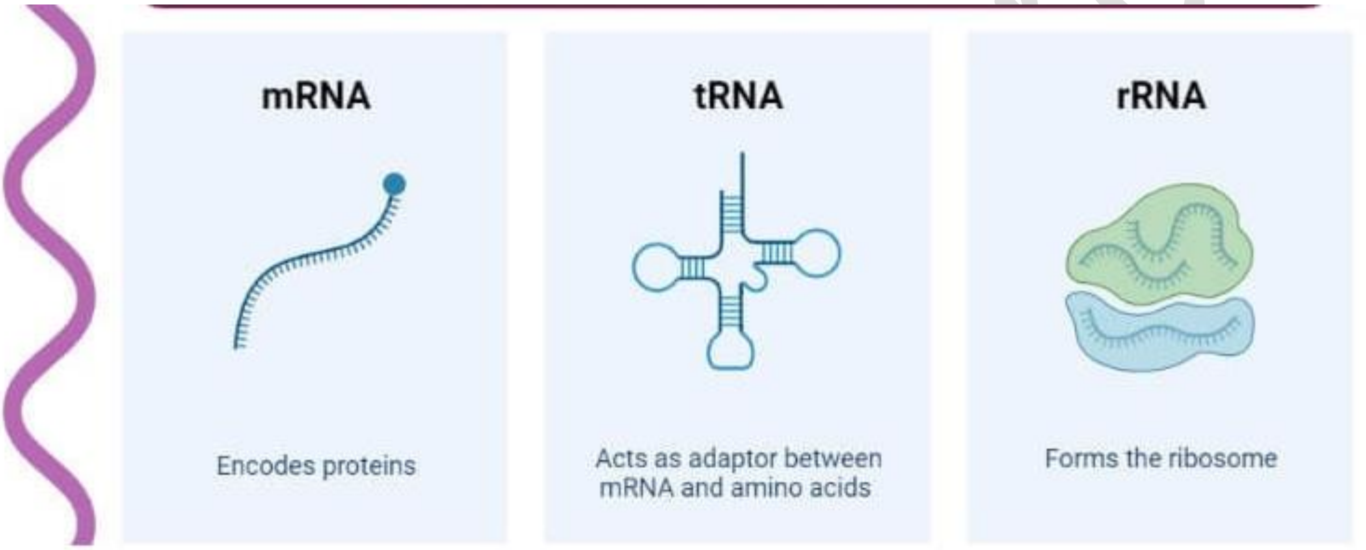


1. **Single-Stranded Molecule**:
   - RNA (Ribonucleic Acid) is typically a single-stranded molecule, although some RNA molecules may fold into complex secondary or tertiary structures.
   - Unlike DNA, RNA contains the sugar ribose instead of deoxyribose and the base uracil (U) instead of thymine (T).
2. **Types of RNA**:
   - Messenger RNA (mRNA): Carries genetic information from DNA to the ribosome for protein synthesis.
   - Transfer RNA (tRNA): Transfers amino acids to the ribosome during protein synthesis.
   - Ribosomal RNA (rRNA): Forms the structural and catalytic core of the ribosome during protein synthesis.
   - Other types include microRNA (miRNA) and small nuclear RNA (snRNA), involved in gene regulation and RNA processing, respectively.
3. **Function**:
   - RNA plays diverse roles in gene expression, including transcription, RNA processing, translation, and regulation of gene expression.

- It serves as an intermediary between DNA and protein and participates in various cellular processes, including RNA interference (RNAi) and post-transcriptional modifications.

Types of RNA- their functions – determining the base sequence of DNA:

Types of RNA:



1. **Messenger RNA (mRNA)**:
    - **Function**:
        - Carries genetic information from the DNA in the nucleus to the ribosome in the cytoplasm.
        - Specifies the sequence of amino acids during protein synthesis.
    - **Process**:
        - mRNA is transcribed from a DNA template during the process of transcription.
        - It undergoes post-transcriptional modifications, such as capping, splicing, and polyadenylation, before being exported to the cytoplasm for translation.
2. **Transfer RNA (tRNA)**:
    - **Function**:
        - Transfers amino acids to the ribosome during protein synthesis.
        - Recognizes the codons on the mRNA and brings the corresponding amino acids to the growing polypeptide chain.
    - **Structure**:

        - tRNA molecules have a characteristic cloverleaf structure with three loops and a site where the amino acid is attached.
        - The anticodon loop contains three nucleotides that recognize and base-pair with the codons on the mRNA.

3. **Ribosomal RNA (rRNA)**:
    - **Function**:
        - Forms the structural and catalytic core of the ribosome, the cellular machinery responsible for protein synthesis.
        - Provides a scaffold for the assembly of ribosomal proteins and facilitates the binding and positioning of tRNA molecules during translation.
    - **Abundance**:
        - rRNA constitutes the majority of RNA within a cell and is essential for ribosome function.
4. **Small Nuclear RNA (snRNA)**:
    - **Function**:
        - Found in the nucleus and involved in RNA processing, particularly in pre-mRNA splicing.
        - Forms complexes with proteins to recognize splice sites on pre-mRNA and catalyze the removal of introns.
    - **Role in Splicing**:
        - snRNAs are integral components of the spliceosome, a large RNA-protein complex responsible for pre-mRNA splicing.
5. **MicroRNA (miRNA)**:
    - **Function**:
        - Regulates gene expression by binding to complementary sequences in the mRNA, leading to mRNA degradation or inhibition of translation.
        - Plays roles in various biological processes, including development, differentiation, and disease.
    - **Post-Transcriptional Regulation**:
        - miRNAs are transcribed from the genome and undergo processing to generate mature miRNAs, which then target specific mRNAs for degradation or translational repression.

Determining the Base Sequence of DNA:

1. **Transcription**:
    - During transcription, RNA polymerase binds to the DNA template strand and synthesizes an mRNA molecule by adding complementary nucleotides.
    - The base sequence of the DNA is transcribed into a complementary RNA sequence, with uracil (U) replacing thymine (T) in the RNA transcript.
2. **RNA Processing**:

- The newly synthesized mRNA undergoes various post-transcriptional modifications, including capping, splicing, and polyadenylation.
- These modifications ensure the stability, integrity, and functionality of the mRNA transcript.

3. **Translation**:
    - The processed mRNA molecule is then transported to the cytoplasm, where it serves as a template for protein synthesis during translation.
    - The sequence of codons on the mRNA is decoded by ribosomes, with each codon specifying the incorporation of a specific amino acid into the growing polypeptide chain.
4. **Protein Synthesis**:
    - The sequence of amino acids in the polypeptide chain is determined by the sequence of codons on the mRNA, which, in turn, reflects the base sequence of the DNA template.
    - Thus, the base sequence of DNA ultimately dictates the amino acid sequence of proteins through the intermediary role of mRNA.