UNIT-V

NUCLEIC ACID

- **Definition, purine and pyrimidine bases**
- **Components of nucleosides and nucleotides with examples**
- **Structure of DNA (Watson and Crick model), RNA and their functions**

Nucleic Acids

Nucleic acids are complex biomolecules that play essential roles in storing, transmitting, and expressing genetic information. They are composed of nucleotide monomers linked together through phosphodiester bonds to form polynucleotide chains. There are two main types of nucleic acids: deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).

Definition:

Nucleic acids are biological macromolecules composed of nucleotide monomers, which are made up of a sugar molecule (deoxyribose in DNA, ribose in RNA), a phosphate group, and a nitrogenous base.

Purine and Pyrimidine Bases:

Nucleotides contain nitrogenous bases, which are of two types:

Purines: Adenine (A) and Guanine (G)

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

Components of Nucleosides and Nucleotides:

Nucleoside

- It consists of a nitrogenous base attached to a sugar molecule (either ribose or deoxyribose), but without the phosphate group.
- Examples include adenosine, guanosine, cytidine, thymidine, and uridine.

Nucleotide

- It consists of a nucleoside **(nitrogenous base + sugar)** and one or more **phosphate groups** attached to the 5' carbon of the sugar.
- Examples include adenosine monophosphate (AMP), guanosine monophosphate (GMP), cytidine monophosphate (CMP), thymidine monophosphate (TMP), and uridine monophosphate (UMP).

Structure of DNA and RNA:

DNA (DEOXYRIBONUCLEIC ACID)

- The structure of DNA, or deoxyribonucleic acid, was elucidated by James Watson and Francis Crick in 1953.
- Their model, known as the Watson-Crick model, provided a groundbreaking understanding of the molecule responsible for heredity.
- The structure of DNA is often depicted as a double helix, with two polynucleotide strands winding around each other.

DNA Types

There are three different DNA types:

- **A-DNA:** It is a right-handed double helix similar to the B-DNA form. Dehydrated DNA takes an A form that protects the DNA during extreme conditions such as desiccation. Protein binding also removes the solvent from DNA, and the DNA takes an A form.
- **B-DNA:** This is the most common DNA conformation and is a right-handed helix. The majority of DNA has a B type conformation under normal physiological conditions.
- **Z-DNA:** Z-DNA is a left-handed DNA where the double helix winds to the left in a zig-zag pattern. It was discovered by Andres Wang and Alexander Rich. It is found ahead of the start site of a gene and hence, is believed to play some role in gene regulation.

Components of DNA

1.Sugar-Phosphate Backbone

- The backbone of the DNA molecule is composed of alternating sugar (deoxyribose) and phosphate groups.
- The sugar and phosphate molecules are covalently bonded together through phosphodiester bonds.

2.Nitrogenous Bases

- Four types of nitrogenous bases are found in DNA: adenine (A), thymine (T), cytosine (C), and guanine (G).
- Adenine forms hydrogen bonds with thymine, and cytosine forms hydrogen bonds with guanine. These base pairs are complementary.

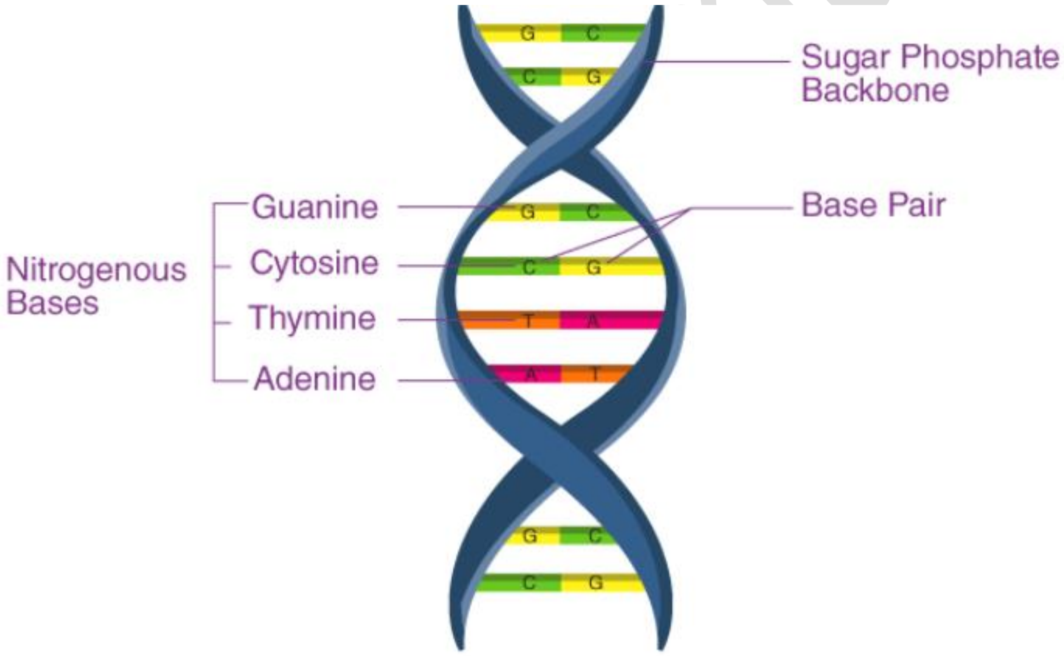
3.Arrangement of DNA

Double Helix

- The DNA molecule consists of two polynucleotide strands that run antiparallel to each other.
- The two strands wind around each other in a right-handed helical structure, forming the double helix.

4.Base Pairing

- Adenine (A) on one strand pairs with thymine (T) on the other strand, forming two hydrogen bonds.
- Cytosine (C) on one strand pairs with guanine (G) on the other strand, forming three hydrogen bonds.
- This base pairing follows the principle of complementary base pairing, where A always pairs with T and C always pairs with G.



5.Major and Minor Grooves

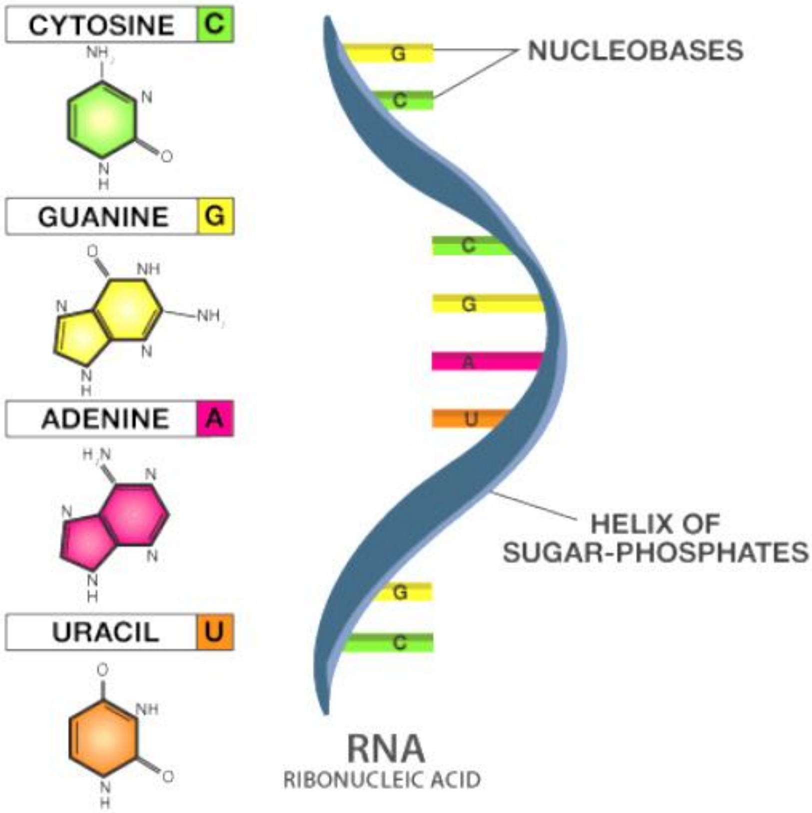
- The double helix structure of DNA forms major and minor grooves along its length.
- These grooves provide sites for protein binding and play a role in DNA-protein interactions involved in processes such as transcription and replication.

Functions

DNA serves as the genetic blueprint for the synthesis of proteins and the transmission of hereditary information from one generation to the next.

RNA (RIBONUCLEIC ACID)

RNA, or ribonucleic acid, is a single-stranded nucleic acid that plays crucial roles in various cellular processes, including protein synthesis, gene regulation, and gene expression. While RNA shares some similarities with DNA, such as the presence of nucleotides and nitrogenous bases, it differs in structure and function.



COMPONENTS OF RNA

1.Sugar-Phosphate Backbone

- Like DNA, RNA also has a sugar-phosphate backbone.
- However, in RNA, the sugar component is ribose instead of deoxyribose.
- The ribose sugar molecule has one more oxygen atom than deoxyribose, hence the name "ribo"nucleic acid.

2.Nitrogenous Bases

- RNA contains four nitrogenous bases: adenine (A), guanine (G), cytosine (C), and uracil (U).
- Uracil replaces thymine (T) found in DNA, and it pairs with adenine via hydrogen bonds during RNA synthesis.

TYPES OF RNA

Messenger RNA (mRNA)

Messenger RNA (mRNA) is a type of RNA molecule that plays a crucial role in protein synthesis. It serves as an intermediate messenger between the genetic information encoded in DNA and the synthesis of proteins in the cell.

Structure of mRNA

Single-Stranded Molecule

- mRNA is typically single-stranded, consisting of a linear sequence of nucleotides.
- It contains a ribose sugar-phosphate backbone with nitrogenous bases (adenine, guanine, cytosine, and uracil) attached to the sugar molecules.

Codons

- The nucleotide sequence of mRNA is divided into codons, each consisting of three consecutive nucleotides.
- Codons encode specific amino acids, and the sequence of codons determines the sequence of amino acids in the synthesized protein.

Function of mRNA

Transcription

- mRNA is synthesized from a DNA template during the process of transcription.
- RNA polymerase enzymes catalyze the synthesis of mRNA by complementary base pairing with the DNA template strand and adding nucleotides according to the genetic code.

Genetic Information Transfer

- mRNA carries the genetic information transcribed from DNA to the ribosomes, which are the cellular organelles where protein synthesis occurs.
- It serves as a template for the translation of the genetic code into the amino acid sequence of proteins.

Protein Synthesis (Translation)

- At the ribosomes, mRNA interacts with transfer RNA (tRNA) molecules, which carry specific amino acids.
- The sequence of codons on the mRNA determines the order in which tRNA molecules bind to the ribosome and deliver their corresponding amino acids.
- Ribosomes catalyze the formation of peptide bonds between adjacent amino acids, resulting in the synthesis of a polypeptide chain based on the mRNA sequence.

Transfer RNA (tRNA)

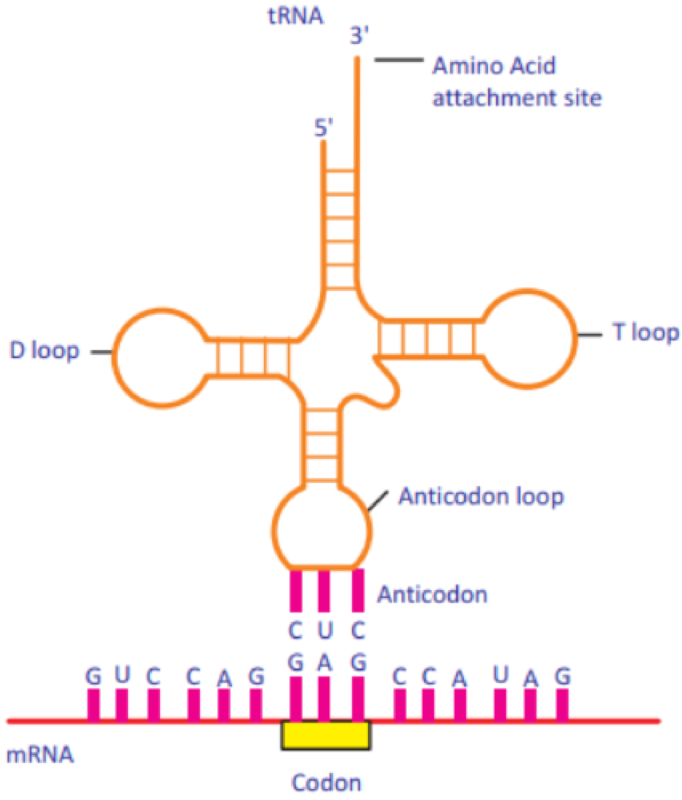
- tRNA is responsible for bringing amino acids to the ribosome during protein synthesis.
- Each tRNA molecule carries a specific amino acid and contains an anticodon region that recognizes and pairs with the codon on the mRNA.

Ribosomal RNA (rRNA)

- rRNA is a structural component of ribosomes, which are the cellular organelles where protein synthesis takes place.
- rRNA interacts with mRNA and tRNA to facilitate protein synthesis.

tRNA

Transfer RNA (tRNA) is a type of RNA molecule that plays a crucial role in protein synthesis by bringing amino acids to the ribosome during translation.



Structure of tRNA

Cloverleaf Structure

1. tRNA molecules adopt a distinctive cloverleaf-like structure.
2. This structure consists of four arms: the acceptor arm, the D-arm, the anticodon arm, and the TψC arm.
3. The acceptor arm contains the 3' end of the tRNA, where the amino acid is attached.
4. The anticodon arm contains the anticodon sequence, which base-pairs with the complementary codon on the mRNA during translation.

Base Pairing:

1. tRNA molecules contain specific sequences of nucleotides, including the anticodon sequence, which is complementary to the codon sequence on mRNA.
2. Base pairing between the anticodon of tRNA and the codon of mRNA ensures that the correct amino acid is added to the growing polypeptide chain during protein synthesis.

Function of tRNA:

1.Amino Acid Transport

- Each tRNA molecule carries a specific amino acid covalently attached to its 3' end.
- Aminoacyl-tRNA synthetases are enzymes responsible for attaching the correct amino acid to its corresponding tRNA molecule, ensuring accuracy in protein synthesis.

2.Translation

- During translation, tRNA molecules recognize and bind to specific codons on the mRNA.
- The anticodon sequence of tRNA base-pairs with the complementary codon sequence on mRNA, allowing the correct amino acid to be added to the growing polypeptide chain.
- tRNA acts as an adaptor molecule, facilitating the accurate translation of the genetic code into the amino acid sequence of proteins.

3.Specificity and Wobble Base Pairing

Specificity:

- Each tRNA molecule is specific for a particular amino acid, determined by the anticodon sequence and the aminoacyl-tRNA synthetase enzyme.
- The specificity of tRNA ensures that the correct amino acid is incorporated into the growing polypeptide chain during translation.

Wobble Base Pairing

- The third nucleotide of the codon (the "wobble" position) and the corresponding nucleotide of the anticodon may exhibit non-standard base pairing.
- This flexibility in base pairing allows some tRNA molecules to recognize multiple codons encoding the same amino acid, contributing to the degeneracy of the genetic code.