Clinical Biochemistry

Rabia Rakhshan

DMLT IST YEAR

Nucleic Acids
DNA
RNA

NUCLEIC ACIDS (POLYNUCLEOTIDES)

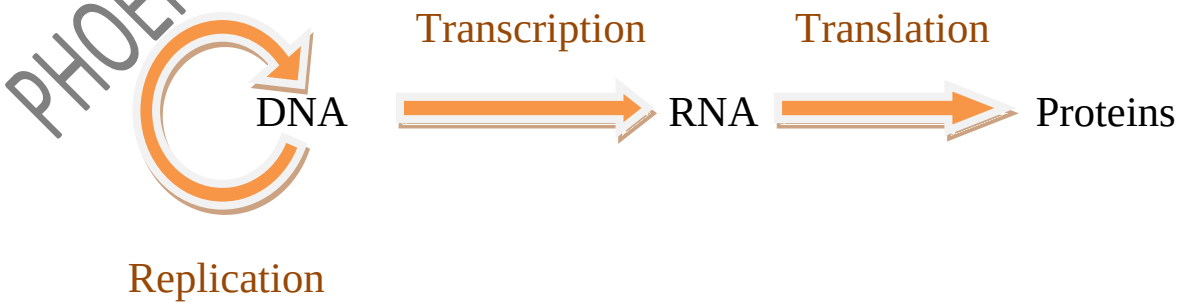
Nucleic acids are the polymers of nucleotides (polynucleotides) held by 3' and 5' phosphate bridges. In other words, nucleic acids are built up by the monomeric units—nucleotides. There are two types of nucleic acids, namely deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). Primarily, nucleic acids serve as repositories and transmitters of genetic information.

DNA (Deoxyribonucleic Acid)

DNA was discovered in ***1869*** by ***Johann Friedrich Miescher***, a Swiss researcher. The demonstration that DNA contained genetic information was first made in ***1944,*** by ***Avery, Macleod and MacCary.***

Functions of DNA

DNA is the chemical basis of heredity and may be regarded as the reserve bank of genetic information. DNA is exclusively responsible for maintaining the identity of different species of organisms over millions of years. Further, every aspect of cellular function is under the control of DNA. The DNA is organized into genes, the fundamental units of genetic information. The genes control the protein synthesis through the mediation of RNA, as shown below:



The interrelationship of these three classes of biomolecules (DNA, RNA and proteins) constitutes the central dogma of molecular biology or more commonly the ***central dogma of life.***

Besides being present in the nucleus of Eukaryotic organisms, DNA is also found in the mitochondria and chloroplast. DNA in these organelles performs specified functions with regard to protein synthesis.

Functions of RNA

RNA performs different types of functions, carried out by these different types of RNA's.

1. Messenger RNA (mRNA): It specifies the sequence of amino acids in the protein synthesis (translation).

2. Ribosomal RNA (rRNA): It is found in combination with proteins and in association with the structure and function of ribosomes; the factories of protein synthesis.

3. Transfer RNA (tRNA): It delivers the amino acids to ribosomes for protein synthesis.

4. RNA as Ribonucleoprotein participates in the post - transcriptional modification of other RNA's.

5. RNA is the genetic material of many viruses.

STRUCTURE OF NUCLEOTIDES

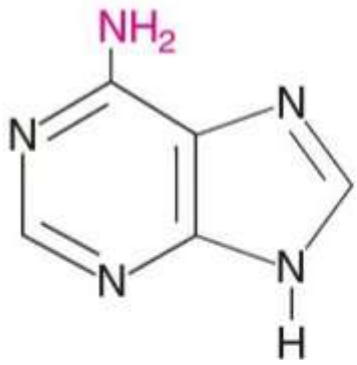
The nucleotide essentially consists of:

- ***Nitrogenous base***
- ***Sugar and***
- ***Phosphate.***

The term ***nucleoside*** refers to ***base + sugar.***

Thus, ***Nucleotide is Nucleoside + Phosphate.***

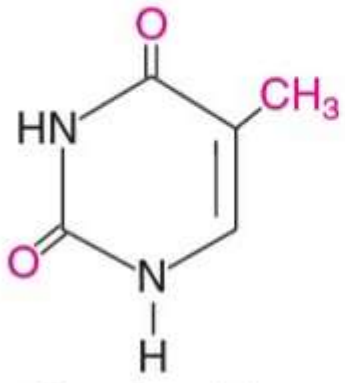
The ***nitrogenous bases*** found in nucleotides (and, therefore, nucleic acids) are aromatic heterocyclic compounds . The bases are of two types—***purines and pyrimidines***. The structures of major purines and pyrimidines found in nucleic acids are shown in Figure below.



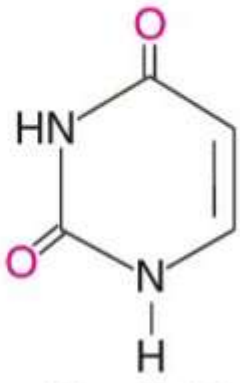
Adenine (A)
(6-aminopurine)

Guanine (G)
(2-amino 6-oxypurine)

Cytosine (C)
(2-oxy 4-aminopyrimidine)



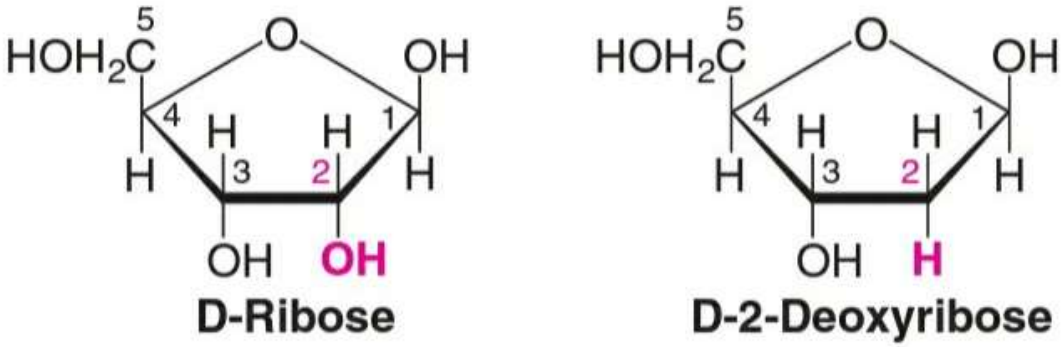
Thymine (T)
(2,4-dioxy-5 methylpyrimidine)



Uracil (U)
(2,4-dioxypyrimidine)

DNA and RNA contain the same purines namely adenine (A) and guanine (G). Further, the pyrimidine cytosine (C) is found in both DNA and RNA. However, the nucleic acids differ with respect to the second pyrimidine base. DNA contains thymine (T) whereas RNA contains uracil (U) . As is observed in the Fig. above, thymine and uracil differ in structure by the presence (in T) or absence (in U) of a methyl group.

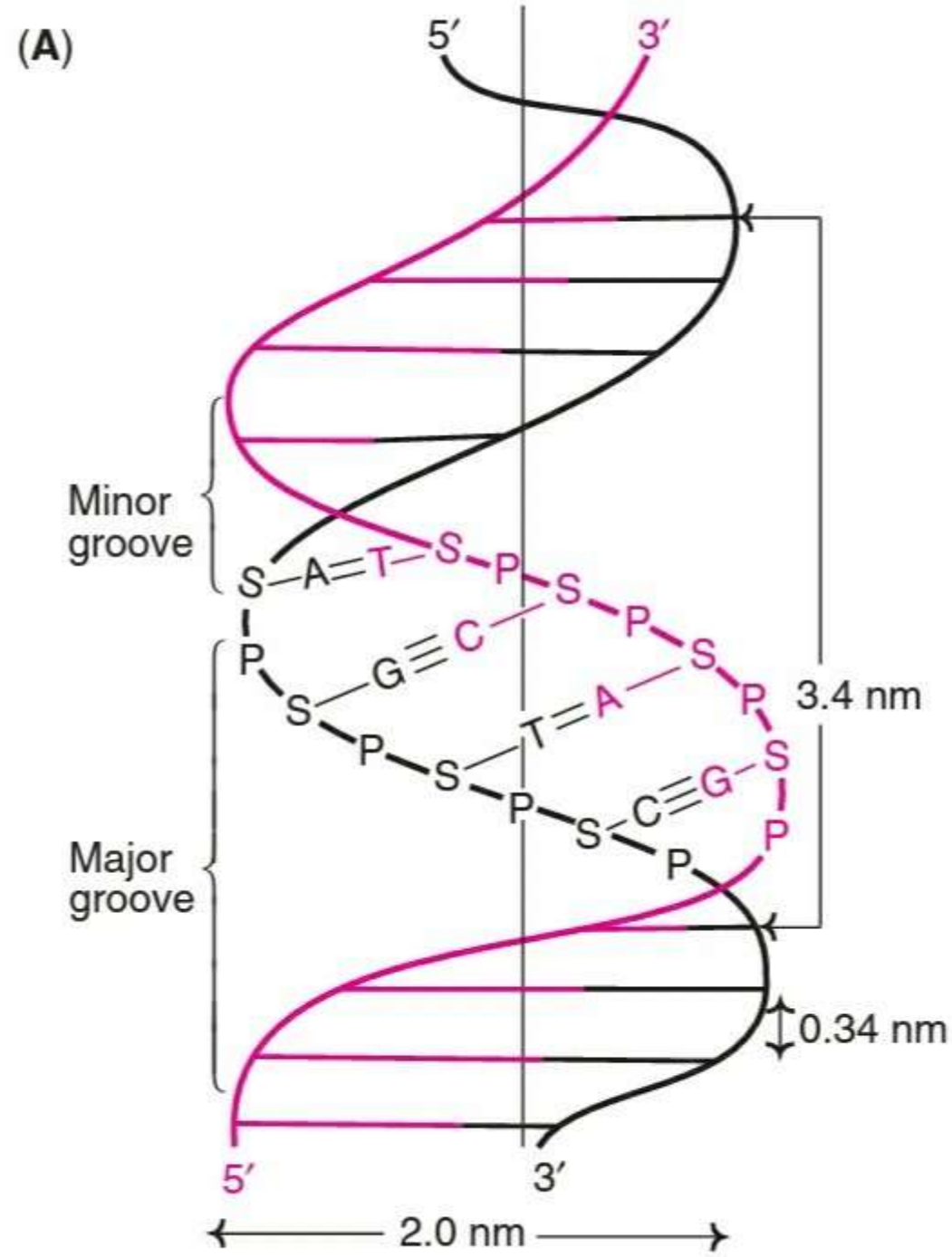
 # Sugars of nucleic acids: The five carbon monosaccharides (pentoses) are found in the nucleic acid structure. RNA contains D-ribose while DNA contains D-deoxyribose. Ribose and deoxyribose differ in structure at C2. Deoxyribose has one oxygen less at C2 compared to ribose (shown in figure below):



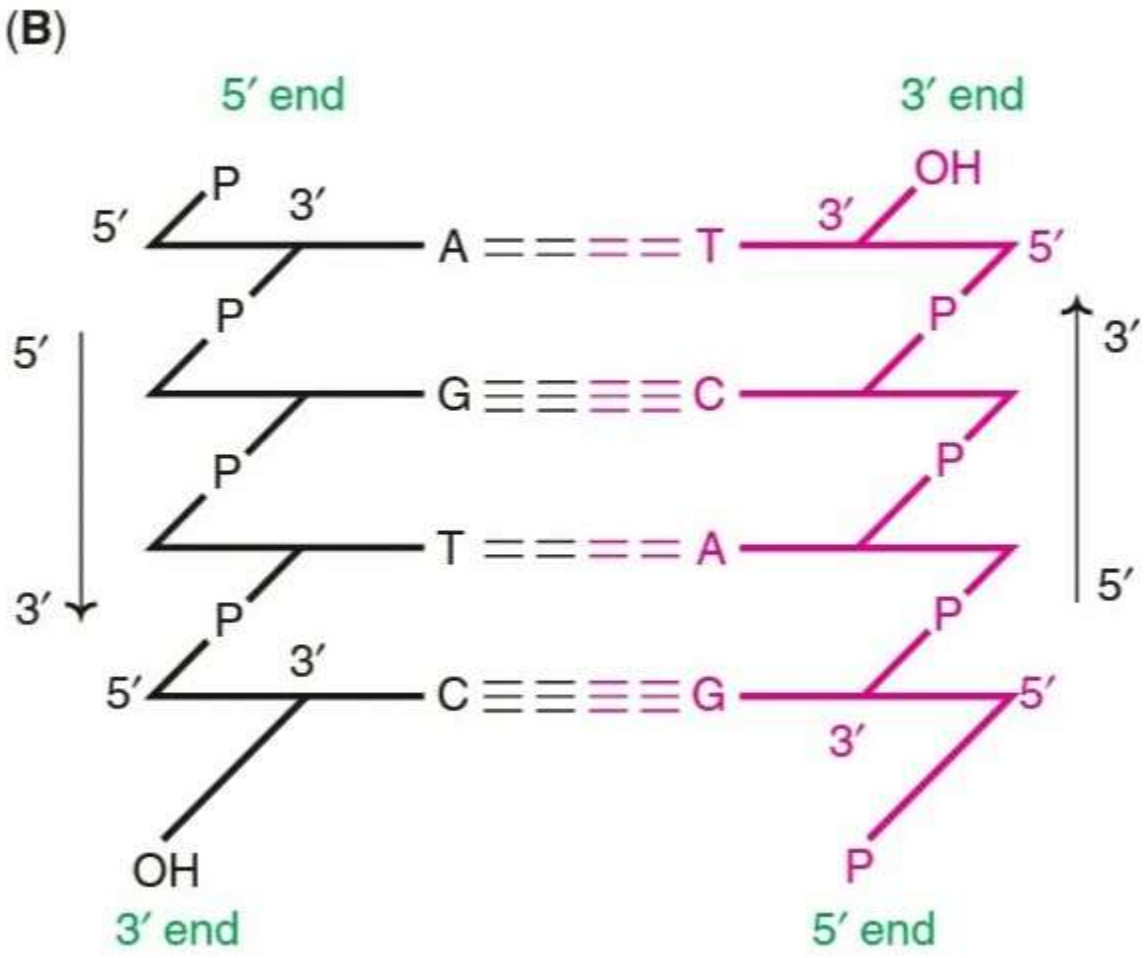
Structures of sugars present in nucleic acids (ribose is found in RNA and deoxyribose in DNA; Note the structural difference at C2).

DNA DOUBLE HELIX

The double helical structure of DNA was proposed by ***James Watson and Francis Crick in 1953*** (Nobel Prize, 1962). The elucidation of DNA structure is considered as a milestone in the era of modern biology. The structure of DNA double helix is comparable to a twisted ladder. The structure is Watson-Crick model of DNA (now known as B-DNA).



(A) Watson–Crick model of DNA helix



(B) Complementary base pairing in DNA helix.

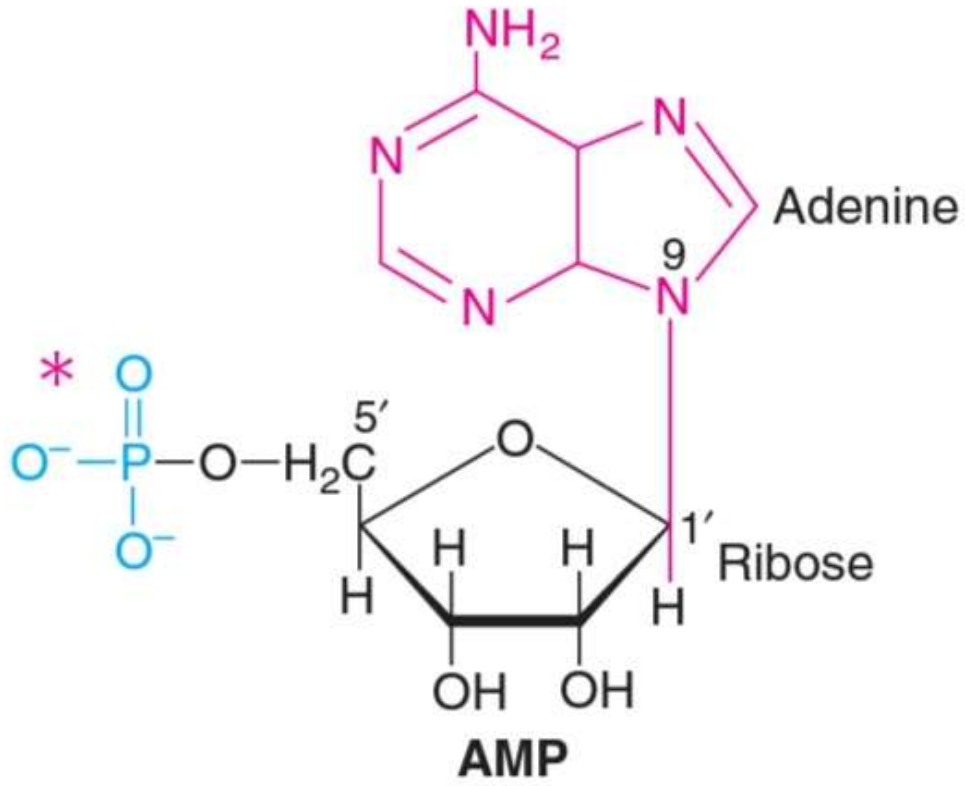
STRUCTURE OF RNA

RNA is a polymer of ribonucleotides held together by 3', 5'-phosphodiester bridges . Although RNA has certain similarities with DNA structure, they have specific differences

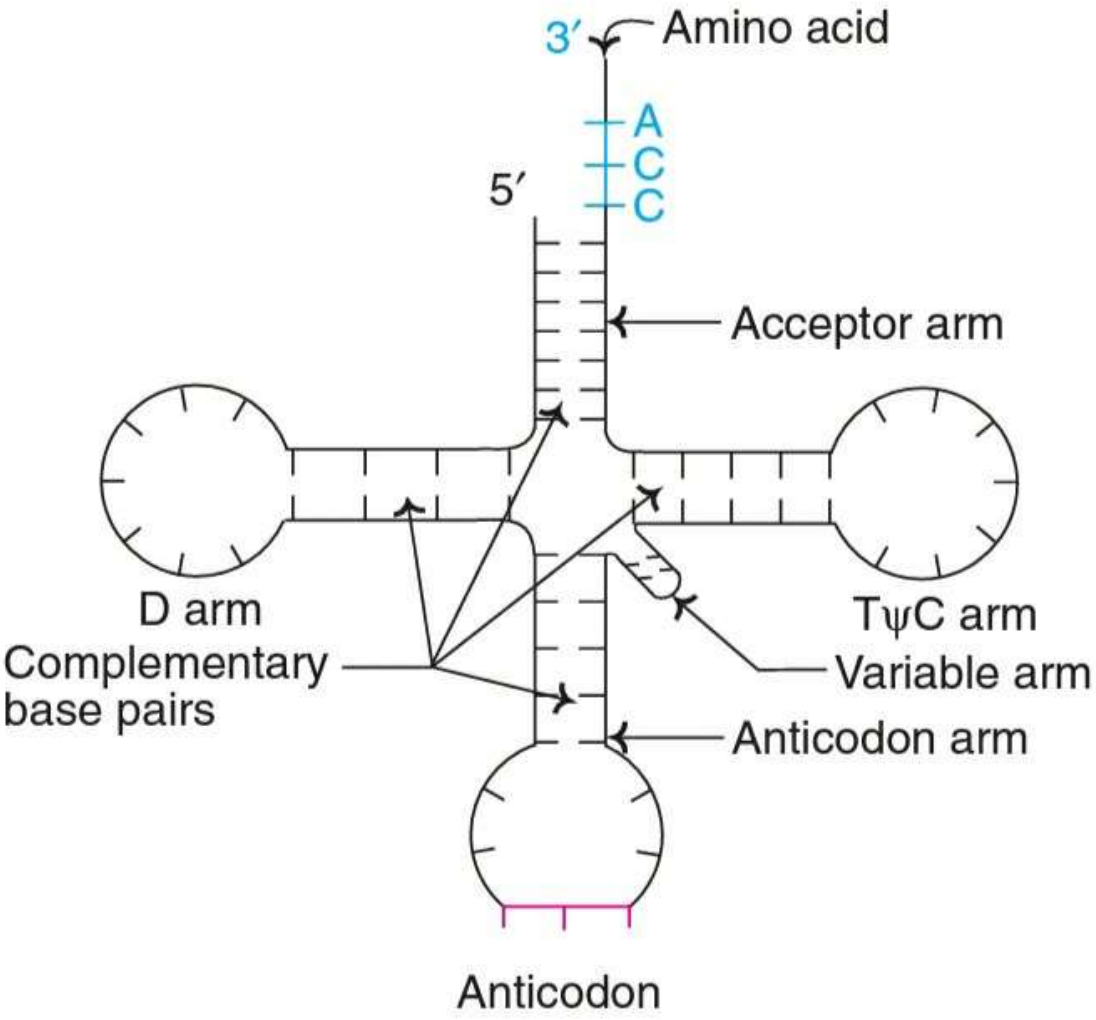
1. Pentose: The sugar in RNA is ribose in contrast to deoxyribose in DNA.

2. Pyrimidine: RNA contains the pyrimidine uracil in place of thymine (in DNA).

3. Single strand: RNA is usually a single- stranded polynucleotide. However, this strand may fold at certain places to give a double-stranded structure, if complementary base pairs are in close proximity.



The structure of adenosine 5' - monophosphate (AMP) [*-Addition of second or third phosphate gives adenosine diphosphate (ADP) and adenosine triphosphate (ATP) respectively].



Structure of tRNA