NUCLEIC ACIDS

These are the acids present in nucleus of the cells so called as nucleic acids. They were first discovered by Meisher in 1868 from pus cells of discarded surgical bandages. He removed a substance called as nuclein and phosphorus from the nucleus. Altmann in 1889 introduced the term nucleic acid to the nuclein. Kossel 1894 discovered that histones and protamines are associated with nucleic acids. He in 1910 demonstrated that two purine and two pyrimidine bases are associated with nucleic acids. These are huge organic molecules that contain Carbon, Hydrogen, Oxygen, Nitrogen and Phosphorus. Two types of nucleic acids are present in living organisms i.e. Deoxyribonucleic Acid (DNA) and Ribonucleic Acid (RNA).

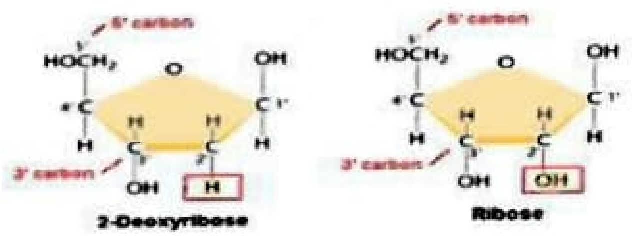
Deoxyribonucleic Acid (DNA)

It is the heaviest molecule of the cell. It is a genetic material from bacteria to higher plants and animals except plant viruses.. in eukaryotic cells it is found in nucleus in chromosomes and bound to proteins to form nucleoproteins. In prokaryotes and viruses there is single molecule of DNA. It is also present in Mitochondria and Chloroplast. In plant and animal cells the DNA is double stranded. In some viruses RNA is genetic material.

STRUCTURE Of DNA

A DNA molecule is an unbranched long chain polymer formed of several thousand pairs of monomeric units called as nucleotides. Each nucleotide is composed of three components namely, a pentose sugar deoxyribose, a nitrogen base and a phosphate group.

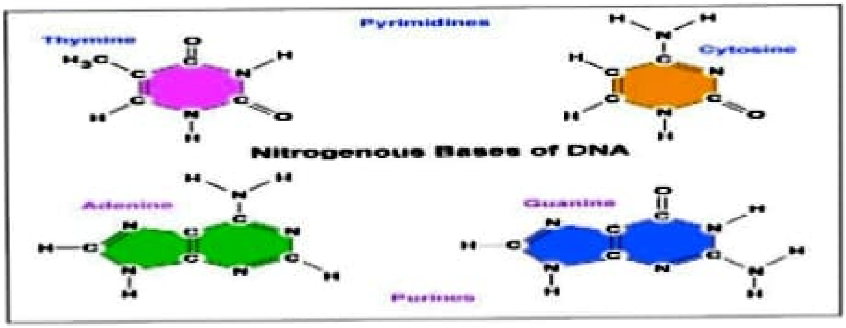
1. **SUGAR** :
   It is a deoxyribose sugar with 5 carbon atoms. It has one less oxygen atom than ribose sugar. The four carbon atoms and a single oxygen atom forms a ring. The fifth carbon atom is present outside the ring.



(Klug & Cummings 1997)

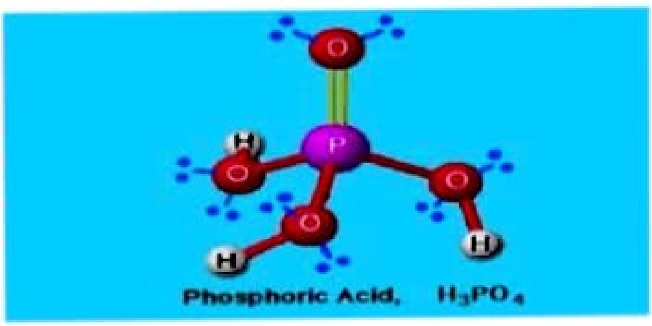
2. Nitrogenous Bases :

These are of two types i.e. pyrimidines and purines. The pyrimidine bases are thymine, cytocine and uracil while the purine bases are adenine and guanine. The pyrimidine bases pairs with purines. In DNA adenine pairs with thymine and cytocine pairs with guanine. In RNA thymine is replaced by uracil.



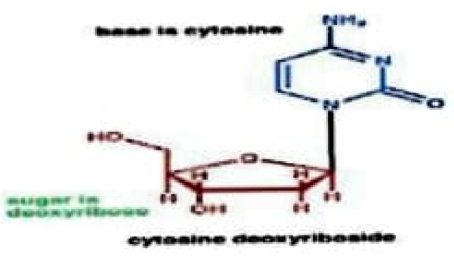
3. Phosphoric Acid :

The phosphate group is attached with sugar at 3[rd] carbon atom on one side and 5[th] carbon atom on other side in a chain.



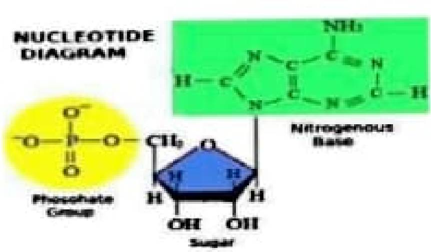
NUCLEOSIDES:

It is a combination of nitrogenous base with pentose sugar. The nitrogenous base is either adenine, thymine, cytocine or guanine while the pentose sugar is deoxyribose. So it is called as deoxyribonucleoside. In RNA it is called as ribonucleoside.



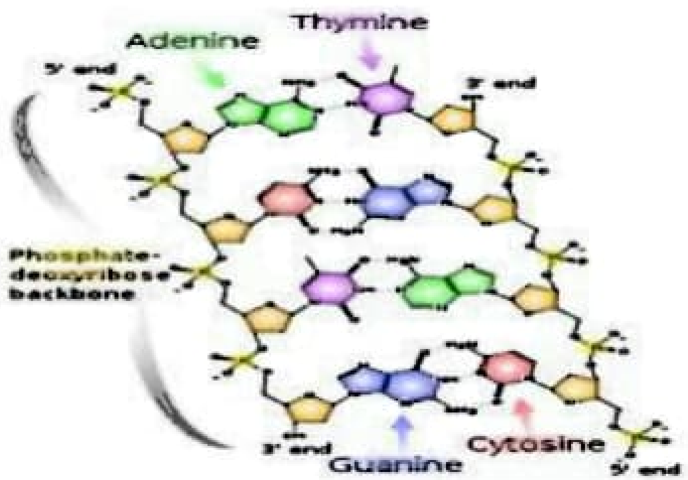
NUCLEOTIDES :

A nucleotide is a pentose sugar attached with nitrogen base and phosphate group. A nucleotide derived from ribonucleoside is called as ribonucleotide.



POLYNUCLEOTIDE CHAIN :

DNA is a macromolecule and is a polymer of long chain made up of thousands of units called as nucleotides. The chain is linked through phosphate groups. The phosphate group is attached to 3[rd] carbon atom of sugar on one side and 5th carbon atom on other side. Thus a chain of nucleotide is formed where sugar and phosphate molecules are arranged in alternate position. The polynucleotide chain show definite polarity or direction. It starts from 5th carbon atom on one end and ends with 3rd carbon atom on other end. Thus in a polynucleotide chain sugar-phosphate-sugar forms the backbone to which nitrogenous bases are attached at right angles.

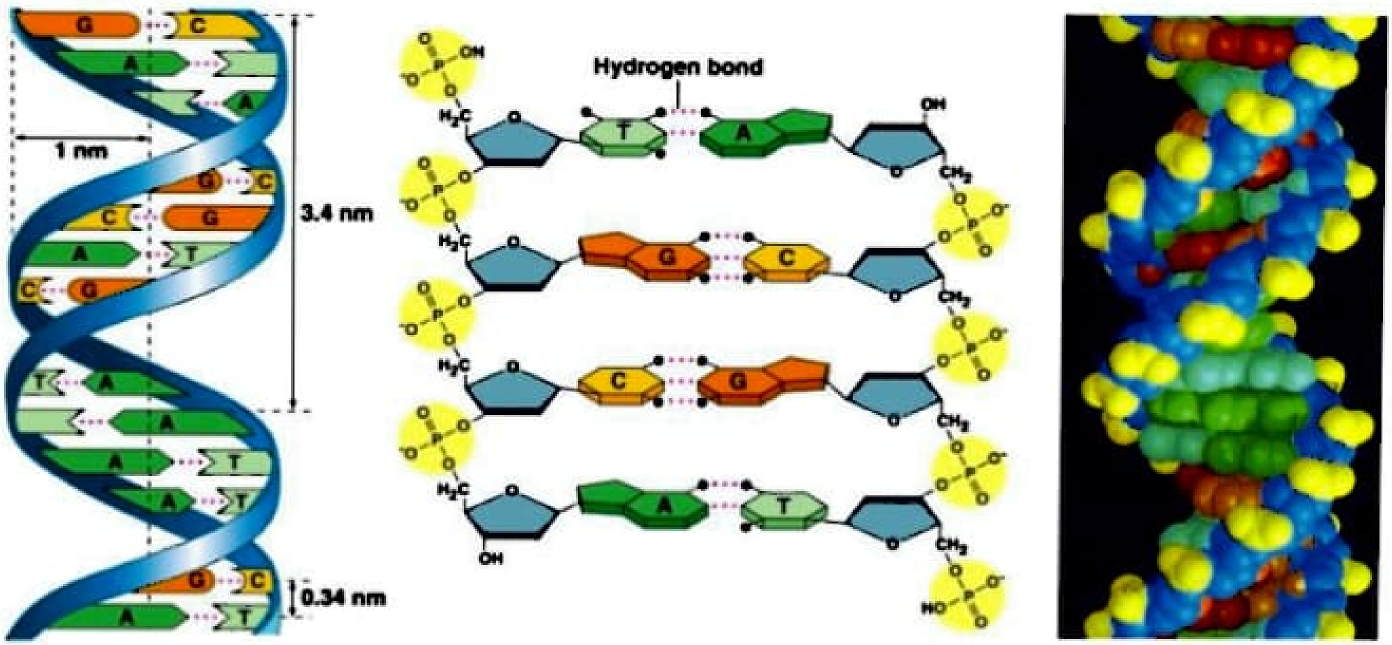


WATSON AND CRICK MODEL OF DNA OR DOUBLE HELIX

In 1953 Watson and Crick proposed a model for DNA molecule. According to this model a DNA molecule is composed of two polynucleotide chains. Each chain is present in opposite direction i.e. they are antiparallel to each other in 5' – 3' and 3' – 5' direction. In such a structure the sugar- phosphate-sugar-phosphate backbone lies on the outside of the molecule while the nitrogenous bases are present at the centre of two chains. These two polynucleotide chain are held together through the hydrogen bonds between the nitrogenous bases. Since the nitrogenous bases are placed at right angles to the axis they appear to be ladder like.

The two polynucleotide chains which are antiparallel twist around central axis to form a right handed double helix which turns downward in a clockwise direction. The two chains are joined together through pairing of nitrogenous bases. The purine bases (A & G) pairs with pyrimidine (T & C) bases. Adenine pairs with Thymine and Cytocine pairs Guanine. Two hydrogen bonds are present between A & T while three Hydrogen bonds are present between C & G. The number of Adenine bases in one chain is equal to number of thymine bases in another chain and the number of cytocine bases in one chain is equal to the number of guanine bases in another chain.

The distance from phosphorus to central axis is 10 A^0 i.e.the width of double helix is 20 A^0 The double helix makes a complete turn every 34 A^0 and the every turn of a double helix has 10 nitrogenous bases. The distance between two base pairs is 3.4 A^0. The twisting of the strands results in formation of deep and shallow grooves and are called as major and minor grooves.



(a) Key features of DNA structure

(b) Partial chemical structure

(c) Space-filling model

FORMS OF DNA

DNA exists in different morphological forms such as A, B, C, D and Z forms. The difference in these forms is on the basis of,

1. The number of base pairs per turn of double helix.
2. The angle between each base pair.
3. The width or diameter of DNA molecule.
4. The handedness of double helix (Right or Left handed)

A – DNA

a. It is left handed and present in environment rich in Na^+ and less of water.
b. It is bulkier than B- Form.
c. It has 11 base pairs per turn and the diameter of the helix is23 A^0.
d. The base pairs are tilted considerable as a result of which the depth of a major groove is increased while that of a minor groove is decreased.

B – DNA

a. It is right handed DNA.
b. It occurs in all living beings under normal conditions.
c. The two strands are twisted in right handed turns with nitrogenous bases roughly placed at right angles to the long axis of the helix.
d. The width of the helix is 20 A^0 .

e. Each turn measures 34 A^0 having 10 base pairs per turn.
f. The distance between each base pair is 3.4 A^0.

C – DNA

a. It results from B-DNA under the conditions here salt concentration is excess and below 66% hydration.
b. It has 9 base pairs per turn with a diameter of 23.7 A^0.

D – DNA

a. It is more or less similar to C- DNA.
b. It has 8 base pairs per turn.

Z- DNA

a. It is left handed DNA. The backbne of the strand follows zig-zag course hence the name Z- DNA
b. The one complete helix has 45 A^0.
c. It has 12 base pairs per turn.
d. The diameter of the helix is 18 A^0.

BIOLOGICAL SIGNIFICANCE OF DNA

1. It is a carrier of genetic information
2. All activities of cell are controlled by DNA of that cell.
3. It controls synthetic activities and plays role in RNA and protein synthesis.
4. DNA may show mutation and leads to evolution.

RNA

It is a unbranched molecule composed of a single polynucleotide chain. Mostly it is single stranded but in some viruses it is double stranded. The single strand is sometimes folded upon itself and in this region the nitrogen bases are complimentary and are joined by nitrogen bonds. It is found in nucleolus but sometimes also found in cytoplasm and ribosomes, mitochondria and chloroplast. RNA can be genetic or nongenetic. The genetic RNA is found in plant and animal viruses and bacteriophages while nongenetic RNA is found in those organisms where DNA is a genetic material

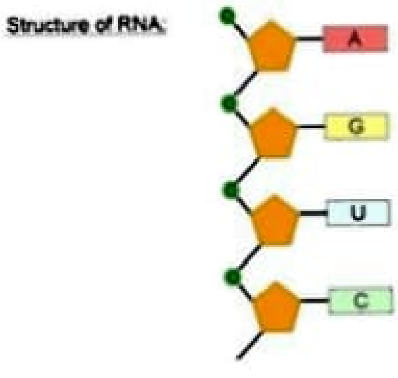
The chemical structure of RNA is very similar to that of DNA, but differs in three main ways:

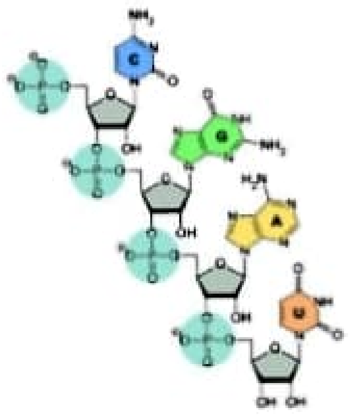
Unlike double-stranded DNA, RNA is a single-stranded molecule in many of its biological roles and has a much shorter chain of nucleotides. However, RNA can, by complementary base pairing, form intrastrand (i.e., single-strand) double helixes, as in tRNA.

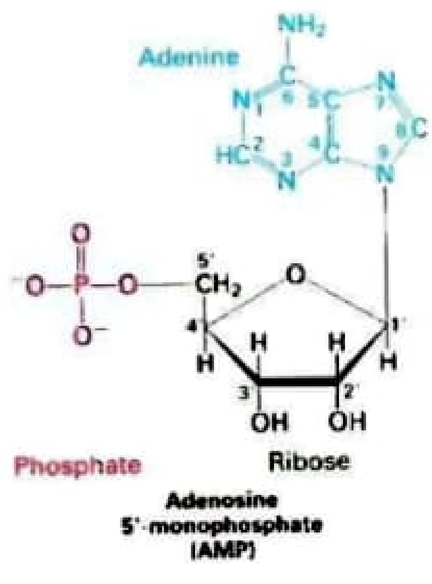
While DNA contains *deoxyribose*, RNA contains *ribose* (in deoxyribose there is no hydroxyl group attached to the pentose ring in the 2' position). These hydroxyl groups make RNA less stable than DNA because it is more prone to hydrolysis.

The complementary base to adenine in DNA is thymine, whereas in RNA, it is uracil, which is an unmethylated form of thymine.

STRUCTURE OF RNA







1. It is a long unbranched polynucleotide chain.
2. It is made of a pentose sugar which is ribose, a phosphate group and nitrogenous bases which are Adenine, Uracil, Cytocine and Guanine.
3. The bases of RNA are arranged on backbone of the chain composed of sugar and a phosphate.
4. Each nucleotide in RNA contains a ribose sugar, with carbons numbered 1' through 5'. A base is attached to the 1' position, in general, adenine (A), cytosine (C), guanine (G), or uracil (U).
5. Adenine and guanine are purines, cytosine and uracil arepyrimidines.
6. A phosphate group is attached to the 3' position of one ribose and the 5' position of the next.
7. The bases form hydrogen bonds between cytosine and guanine, between adenine and uracil and between.
8. An important structural feature of RNA that distinguishes it from DNA is the presence of a hydroxyl group at the 2' position of the ribose sugar.

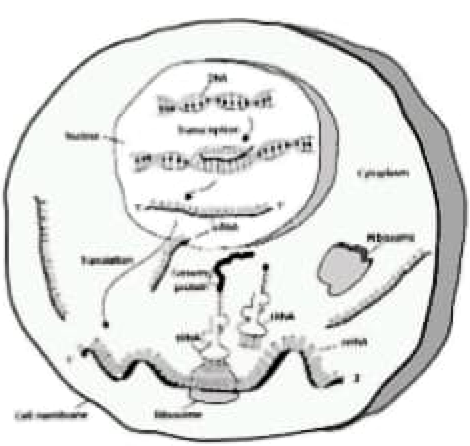
TYPES OF RNA

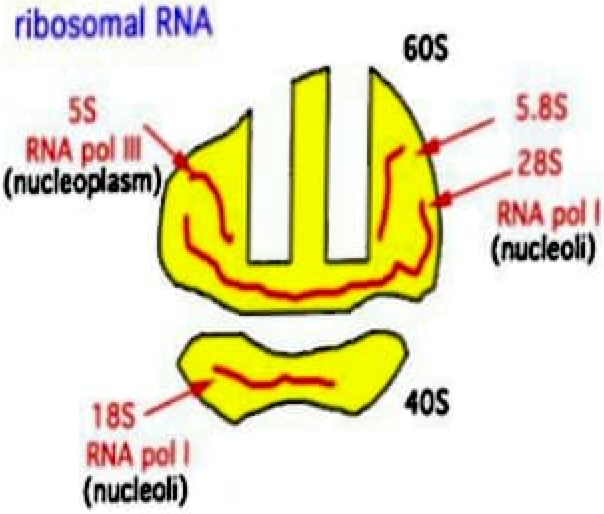
The nongenetic RNA is of following types

1. Messenger RNA (mRNA) or Template RNA
2. Ribosomal RNA or rRNA
3. Transfer RNA or t RNA or Soluble RNA or sRNA .

1. Messenger RNA or mRNA

a. It is always single stranded and constitutes 3 to 5 % of total RNA.
b. It is synthesized on template DNA strand in presence of enzyme RNA polymerase.
c. It carries genetic information to cytoplasm for protein synthesis.
d. Each gene transcribes its own m RNA.
e. Each cell has about 100 to 10000 types of mRNA.
f. Synthesis of mRNA begins at 5' end and proceeds at 3'end.
g. mRNA is unstable but may last for few hours to days in the cytoplasm.





2. Ribosomal RNA or r RNA :

a. It constitutes up to 80% of total RNA and present in ribosomes.
b. It consists of single polynucleotide chain which is twisted upon itself in some regions.
c. In the coiled regions most of the base pairs are complementary and are joined together by hydrogen bonds.
d. The base sequence of rRNA is complementary to the that of DNA template

3. Transfer RNA or tRNA :-

a. It is also called as Soluble or sRNA.

b. It constitutes about 10 to 15 % of total RNA and present in cytoplasm.

c. It is small single stranded and globular and consists of 73 to 93 nucleotides.

d. It is synthesized on DNA template.

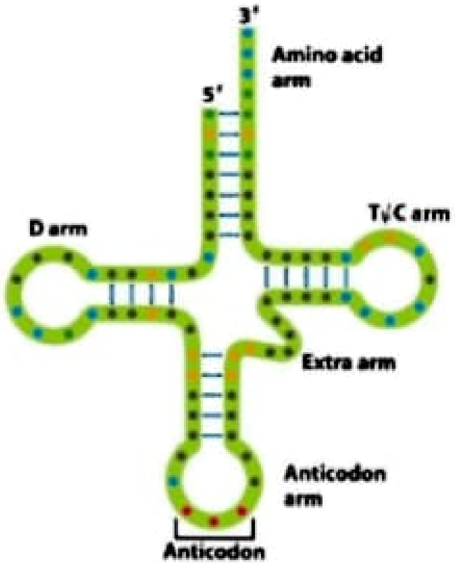
e. It carries amino acids to the mRNA during protein synthesis.

f. Each t RNA carries a specific amino acid.

g. There are at least about 20 types of tRNA for 20 types of amino acids.

h. But there are many tRNA for single amino acid.

i. To explain structure of tRNA cloverleaf model was proposed by Holley



Clover Leaf Model of tRNA

According to this model the single polynucleotide chain of tRNA is folded upon itself to form arms and loops. The folds are stabilized by hydrogen bonds complementary bases in different regions of strand. The 3' end and 5' end lies at same end. The tRNA has following arms and loops.

a. **Acceptor arm**- it consists of a stem of 7 paired bases and a sequence of 4 unpaired nucleotides. Towards 3' end it has a constant region of CCA. The 5' end has either G or C.

b. **D Arm** – it consists of 15 to 18 nucleotides of which 3-4 base pairs forms stem while remaining 7-11 are unpaired nucleotides.

c. Anticodon Arm – it consists of an anticodon arm stem with 5 base pairs and loop called Loop II or anticodon loop with 7 unpaired bases. Of these 7 bases middle 3 bases are anticodon. It recognizes 3 complementary bases on codons on m RNA

d. Variable arm or Extra arm – It is also called as lump or loop III. It contais 5-5 bases.

e. TψC arm – it has a stem of 5 base pairs and a loop of 7 nucleotides.

BIOLOGICAL SIGNIFICANCE OF RNA

1. Is is a genetic material in some plant and animal viruses.
2. The nongenetic mRNA, rRNA and tRNA plays role in protein synthesis.