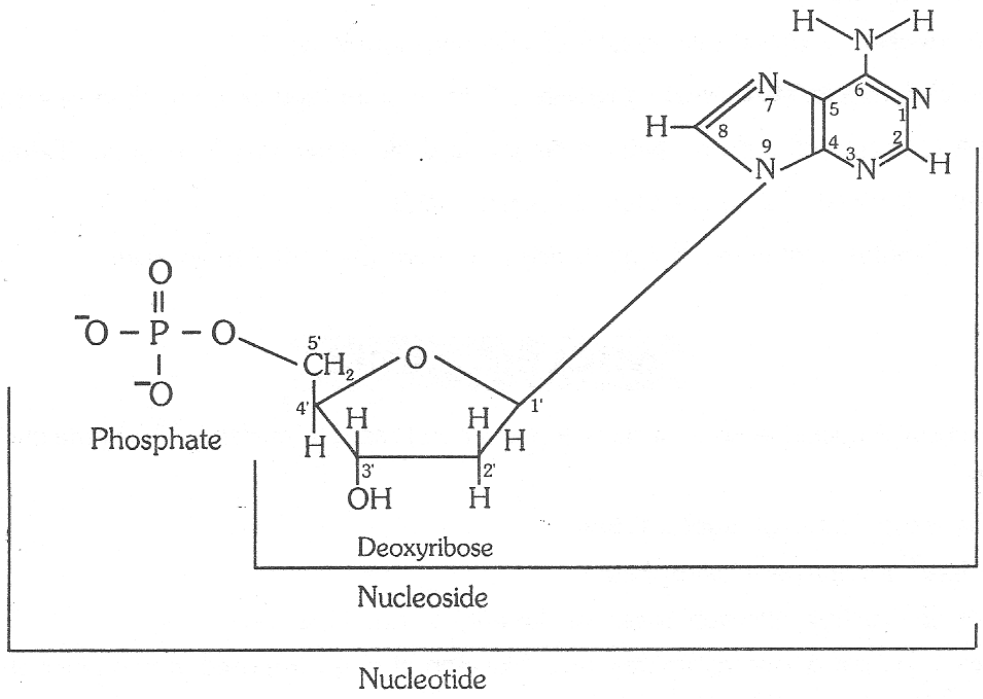
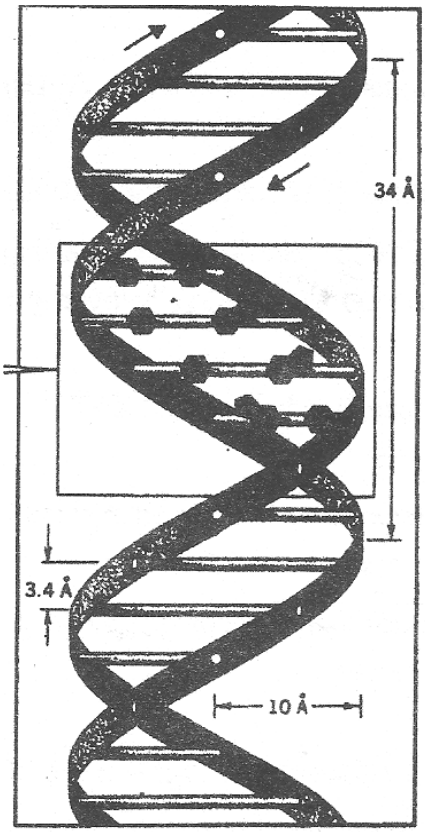


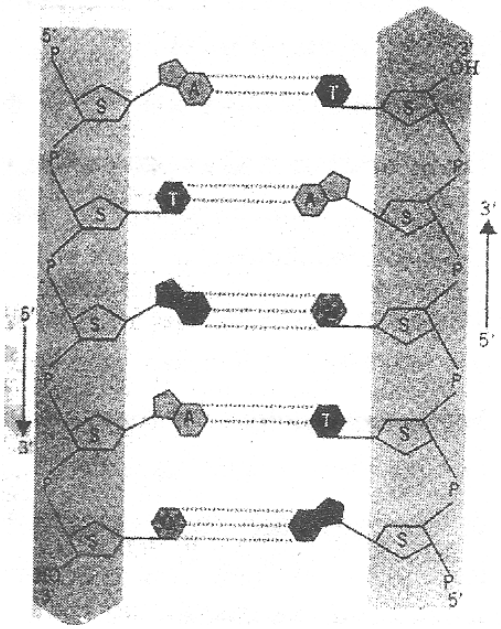
Types of Nucleosides and Nucleotides

1. Adenine + Ribose = Adenosine
   Adenosine + Phosphate = Adenylic acid
2. Adenine + Deoxyribose = Deoxy adenosine
   Deoxy adenosine + P = Deoxy adenylic acid
3. Guanine + Ribose = Guanosine
   Guanosine + P = Guanylic acid
4. Guanine + Deoxyribose = Deoxy gaunosine
   Deoxy guanosine + P = Deoxy guanylic acid
5. Cytosine + Ribose = Cytidine
   Cytidine + P = Cytidylic acid
6. Cytosine + Deoxyribose = Deoxycytidine
   Deoxycytidine + P = Deoxycytidylic acid
7. Uracil + Ribose = Uridine
   Uridine + P = Uridylic acid
8. Thymine + Deoxyribose = Deoxy thymidine
   Deoxythymidine + P = Deoxythymidylic acid

DNA

- Discovered by - **Meischer**
- DNA term given by - **Zacharis**
- In DNA pentose sugar is deoxyribose sugar and four types of nitrogen bases A,T,G,C
- **Wilkins** and **Franklin** studied DNA molecule with the help of X-Ray crystallography.





- With the help of this study, **Watson** and **Crick** (1953) proposed a double helix model for DNA. For this molel Watson, Crick and Wilkins were awarded by noble prize in 1962.
- According to this model, DNA is composed of two polynucleotide chains.
- Both polynucleotide chains are complementary and antiparallel to each other.
- In both strand of DNA direction of phosphodiester bond is opposite i.e. If direction of phospodiester bond in one strand of DNA held together by Hydrogen bonds. These hydrogen bonds are present between Nitrogen bases of both strand.
- Adenine binds to Thymine by two hydrogen bonds and cytosine bind to Guanine by three hydrogen bonds.
- **Chargaff's equivalency rule** - In a double stranded DNA amount of purine nucleotides is equals to amount of pyrimidine nucleotides.

  Purine = Pyrimidine

  [A] + [G] = [T] + [C]

  $$\frac{[A]+[G]}{[T]+[C]} = 1$$

- **Base ratio =** $\frac{A+T}{G+C}$ = constant for a given species.
- In a DNA A + T > G + C $\Rightarrow$ A - T type DNA. Base ratio of A - T type of DNA is more than one. e.g. Eucaryotic DNA
- In a DNA G + C > A + T $\Rightarrow$ G - C type DNA. Base ratio of G - C type of DNA is less than one eg. Procaryotic DNA
- Melting point of DNA depends on G - C contents.

  More G - C contents then more Melting point.

  T_m = Temperature of melting.

  T_m = of procaryotic DNA > T_m of Eucaryotic DNA

- DNA absorbs U.V. rays means 2600Å @ wavelength.
- Out of two strand of DNA only one strand participates in transcription, it is called **Antisense strand/Non coding strand/Template strand.**
- Other strand of DNA which does not participate in transcription is called **sence strand/oding strand.**
- **Denaturation and renaturation of DNA** - If a normal DNA molecule is placed at high temperature (80-90^{0}C) then both strand of DNA will separate to each other due to breaking of hydrogen bonds. It is called DNA-denaturation. When denatured DNA molecule is placed at normal temperature then both strand of DNA attached and recoiled to each other. It is called Renaturation of DNA.
- **Hyperchromicity** - When a double strainded DNA is denturaed by heating then denatured DNA molecule less amount of light. This pnenomenon is called phypochromicity.

Configuration of DNA Molecule :

- Two trands of DNA are helically coiled like a revolving ladder. Back bone of this ladder (Eiling) is composed of phosphate and sugars while steps (bars) composed of pairs of nitrogen bases.
- Distance between two successive steps in 3.4 A^0. In one complete turn of DNA molecule there are such 10 steps (10 pairs of nitrogen bases). So the lenght of one complete turn is 34 A^0. This is called halix length.
- Diameter of DNA molecule i.e. distance between phosphates of two strands is 20A^0.
- Distance between sugar of two strands is 11.1 A^0.
- Lenght of hydrogen bonds between nitrogen bases is 2.8 - 3.0 A^0. Angle between nitrogen base and C_1 Carbon of pentose is 51^0.
- Molecular weight of DNA is 10^6 to 10^9 dalton.
- In nucleus of eucryotes the DNA is associated with histone protein to form nucleoprotein. Histone occupies major groove of DNA at 30^0 angle.
- Bond between DNA and Histone is salt linkage (Mg+).
- DNA is chromosomes is linear while is procaryotes, mitochondria and chloroplast it is circular.
- In $\phi \times 174$ bacteriophage the DNA is single stranded and circular isolated by Sinsheimer.
  G-4, S-13, M-13, F_1 and Dd- Bateriophages also contain ss-circular DNA.

Types of DNA :

On the basis of direction of twisting, there are two types of DNA.

1. **Right Hnaded DNA -**

DNA	Helix Length	No. of base pairs	Distance between two pairs	Diameter
'A'	28 A^0	11 pairs	2.56 A^0	23 A^0
'B'	34 A^0	10 pairs	3.4 A^0	20 A^0
'C'	31 A^0	9.33 pairs	3.32 A^0	19 A^0
'D'	24.24 A^0	8 pairs	3.03 A^0	19 A^0

2. **Left handed DNA :**

Anticlockwise twisting e.g. Z-DNA -discovered by Rich. Phosphate and sugar backbone is zig-zab. Units of Z-DNA are dinucleotides (purine and pyrimidine in alternate order)

Helix length - 45.6 A^0

Diameter - 18.4 A^0

No. of base pairs - 12 (6 dimers)

Distnce between base - pairs - 3.75 A^0

- **Palindromic DNA**- Wilson and Thomas

$\longrightarrow$

C C G G T A C C G G

G G C C A T G G C C

$\longrightarrow$

Sequence of nucleotides same form both ends.

Especial Points :

- DNA molecule is Dextrorotatory while RNA molecule is Laevoratory.
- **C - value** = Total amount of DNA in a haploid genome of organism

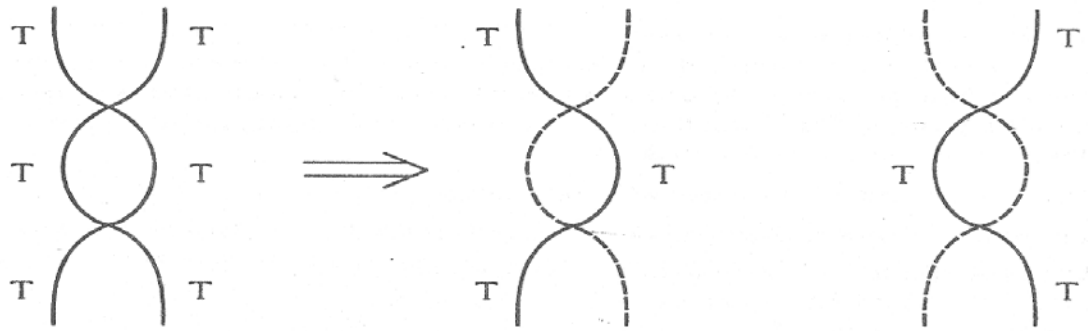
D.N.A. REPLICATION

- All living beings have the capacity to reproduce because of this characteristic of D.N.A.
- D.N.A. replication takes place in "S- Phase" of the cell cycle. At the time of cell division, it divides in equal parts in the daughter cells. Dellbruck suggested three methods of DNA - replication i.e.

(1) Dispersive (2) Conservative (3) Semi - conservative

SEMI CONSERVATIVE MODE OF D.N.A. REPLICATION

Semi conservative mode of D.N.A. replication was first theoritically proposed by **Watson & Crick.** Later on it was experimentally proved by **Meselson & Stahl** (1958) on ***E - Coli*** and ***Taylor*** on ***Viccia faba.*** To prove this method, they used Radiotracer Technique in which Radioisotopes are used. Meselson and Stahl used N^{15} and Cairns (1963) used radioactive Thymidine (with H^3).



- Due to the replication of active Thymidine containing D.N.A., two D.N.A. molecules were obtained in which 50% radioactivity was found.

- When these two D.N.A. molecules containing active Thymidine were made to replicate, the next time four D.N.A. molecules were obtained. Out of these 4 D.N.A., 2 D.N.A. molecules were radioactive and remaining 2 were not radioactive.
- In the same sequence the obtained D.N.A. molecules were further made to replicate then also, the no : of radioactive D.N.A. remains 2.

MECHANISM OF D.N.A. REPLICATION

The following steps are included in D.N.A. replication :

(1) **Unzipping :**

- The separation of 2 chains of D.N.A. is termed as unzipping. And it takes place due to the breaking of H bonds. The process of unzipping starts at a certain specific point which is termed as **initiation point** or **origin of replication.** In procaryotes there occur only one origin of replication but in eucaryotes there occur many origin of replication i.e. unzipping starts at many points simultaneously. At the place of origin, the topoisomerase enzyme (a type of endonuclease) induces a cut in one strand of DNA (Nicking) to relax the two strand of DNA.
- The enzyme responsible for unzipping (breaking the hydrogen bonds) is Helicase (= Swivelase). In the process of unzipping Mg^{+2} ct as cofactor. Unzipping takes place in alkaline medium.
- A protein, "Helix destabilizing protein" prevents recoiling of two separated strands during the process of replication. An another protein SSB (single stranded DNA binding protein) prevents the formation of bends or loops in separated strands.

  DNA - Gyrase - A type of topoisomerase prevents supercoiling of DNA.

  Note :

  The process of D.N.A. replication takes a few minutes in prokaryotes and a few hours in Eukaryotes.

(2) **Formation of New Chain :**

- To start the synthesis of new chain, special type of R.N.A. is required which is termed as **R.N.A. Primer** The formation of R.N.A. primer is catalysed by an enzyme - **R.N.A. Polymerase** (primase). Synthesis o RNA - primer takes place in 5' $\rightarrow$ 3" direction. After the formation of new chain, this R.N.A. is removed. For the formation of new chain Nucleotides are obtained from Nuceloplasm. In the nucleoplasm, Nucleotides are present in the form of triphosphates lke dATP, dGTP, dCTP, dTTP etc.
- During replication, the 2 phosphate groups of all Nucleotides are separated. In this process energy is yielded which is consumed in D.N.A. replication. So, it is cleat that D.N.A. does not depend on mitochondria for it's energy requirements.
- The formatioin of new chain always takes plae in 5' - 3" direction. As a result of this, one chain of D.N.A is continuously formed and it is termed as **Leading strand.** The formation of second chain begins from the centre and not form the terminal points, so this chain is discontinuous and is made up of small segments called **Okazaki Fragments.** This discontinous chain is termed s **Lagging strand** Ultimately all these segments joined together and a complete new chain is formed.
- The Okazaki segments are joined toghether by an enzyme DNA Liagse. (Khorana)
- The formation of enw chain is catalysed by an enzyme **DNA Polymerase.** In prokaryotes it is of 3 types.

  (1) **DNA - Polymerase I :** This was discovered by **KORNBERG** (1957). So it is also called as 'Kornberg's' enzyme'. Kornberg also synthesized DNA first of all, in the laboratory. This enzyme functions as exonuclease. It separates RNA - primer from DNA and also fills the gap. It is also known as DNA - repair enzyme.

(2) **DNA - Polymerase II :** It is least reactive replication process. It is also helpful in DNA - repairing is absence of DNA - polymerase-I and DNA polymerase -III

(3) **DNA - Polymerase III:** This is the main enzyme in DNA - Replication. It is mot important. It was discovered by **Delucia and Cairns.** The larger chains are formed by this enzyme. This is also known as **replicase.**

DNA - polymerase III is a complex enzyme composed of seven polypeptides $\alpha, \varepsilon, \theta, \beta, \gamma_1, \delta, \gamma_2$

In Eukaryotes, there occur five types of DNA - polymerase enzyme.

(1) α -**DNA- polymerase** = Similar of DNA - polymerase I

(2) β -**DNA- polymerase** = It concerned with DNA repair.

(3) γ -**DNA- polymerase** = It concerned with replication of cytoplasmic DNA.

(4) δ -**DNA- polymerase** = Similar to DNA - polymerase II

(5) ε -**DNA- polymerase** = Similar to DNA - polymerase III

- Thus DNA - Replication process is completed with the effect of different enzymes.
- In the semi conservative mode of replication each daughter DNA molecule receives one chain of polynucleotides from the mother DNA - molecule and the second chain is synthesized.

Especial Point :

All DNA polyerase, I, II and III enzymes have 5'-3" polymeristaion activity and 3'-5" exonuclease activity.

RIBO NUCLEIC ACID (RNA)

Structure of RNA is fundamentally the same as DNA, but there are some differnces. The differences are as follows :

(1) In place of De - oxyribose sugar of DNA, there is present Ribose sugar in RNA.

(2) In place of nitrogen base Thymine present in DNa, there is present nitrogen base uracil in RNA.

(3) RNA is made up of only one polynucleotide chain i.e. R.N.A. is **Single stranded.**

Exception :

RNA found in Reo - virus is double sranded, ie. it has two polynucelotide chains.

Type of RNA :

1. **Genetic RNA or Genomic RNA** - In the absence of DNA, sometime RNA working as genetic material and genomic RNA transfer informatioins from on generation to next generation.
   eg. Reo virus, TMV, QB bacteriophge.
2. **Non-genetic RNA - 3 types -**
   (A) r - RNA (B) t - RNA (3) m - RNA

(1) **Ribosomal RNA** (r - RNA):

- This RNA is 80% of the cell's total RNA
- It is found in ribosomes and it is produced in nucleolus.
- It is the most stable form of RNA.
- There are present **80s** type of ribosomes in Eukaryotic cells. Their subunits are **60s** and **40s**. In **60s** sub unit of ribosome three types of r-RNA are found - 5s, 5.8s, 28s
- In the same way 40**s** sub unit of ribosome has only one type of r-RNA - 18**s.**

- So 50**s** ribosome has total 4 molecules of r-RNA.
- prokaryotic cells ahve 70**s** type of ribosomes and its subunits are 50s and 30s.
- 50s sub unit or bisome contains **2 molecules** of r-RNA = 5s and 23s
- 30s sub unit of ribosome has 16s type of r-RNA.
- SO 70s RNA has total 3 molecules of r-RANA

Function :-

- At the time of protein synthesis r-RNA provides attachment site to t-RNA and m-RNA and attahces them on the Ribosome.
- The bonds formed between them are known s **Salt linkages**. It attaches t-RNA to the larger subunit of Ribosome and m - RNA to samller subunit of ribosome.

(2) **Transfer - RNA (t-RNA):**

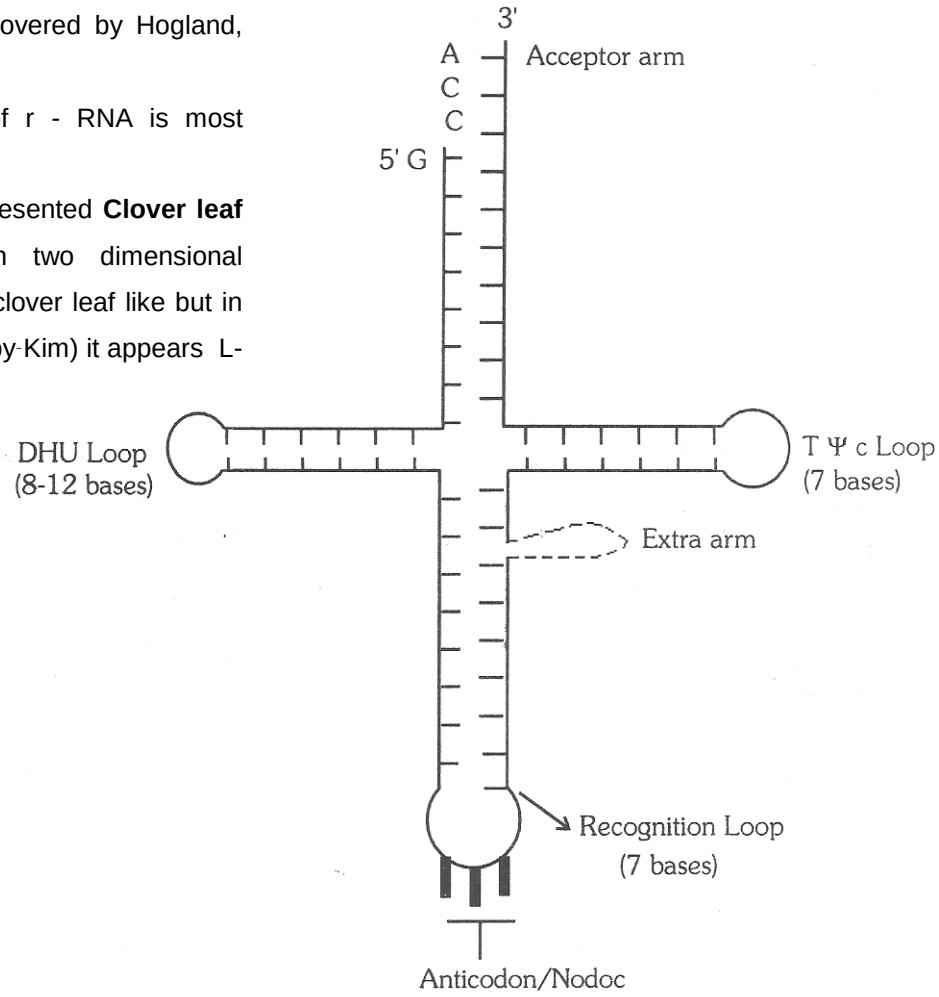
- It is 10-15% of total RNA.
- It is synthesized in the nucleus by DNA.
- It is also known as soluble RNA (sRNA)
- It is also known as Adapter RNA.
- it is the smallest RNA (4s).

Function : At the time of rptoein synthesis it acts as a carrier of amino-acids.

Discovery : t-RNA was disvovered by Hogland, Zemecknike and Stephenson.

Structure : The structure of r - RNA is most complicated.

A scientists named **Holley** presented **Clover leaf model** of its strucutre. In two dimensional structure the t-RNA appears clover leaf like but in three dimensioinal structure (by Kim) it appears L-shaped.



- The molecuel of t - RNA is of single strand.
- There are present three nucleotides in a particular sequence at 3' end of t - RNA and that sequence is = CCA.
- All the 5' ends i.e. last ends are having G (guanine).
- 3' end is known as Acceptor end.
- t-RNA accepts amino acids at acceptor points. Amino acid binds to 3' end by its - COOH group.
- The molecule of t - RNA is folded and due to folding some complementary nitrogenous bases come across with each other and form hydrogen bonds.
- There are some places where hydrogen bonds are not formed, these places are known as loop.

Loops :

There are some abnormal nitrogenous bases in the loops, that is why hydroben bonds are not formed.

e.g. Inosine (I) Pseudouracil (ψ) Dihydrouridine (DHU)

(1) **T ψ C Loop or Attachmend loop :**

This loop connets t - RNA to the larger subunit of ribosome.

(2) **Recognition Loop :**

- This is the most specific loop of t - RNA and different types of t - RNA are different due to this loop. There is a specific sequence of three nucleotides called **Anticodon,** is present at the end of this loop.
- On the basis of Anticodon, there are total 61 types of t - RNA, or, wer can also say that there are 61 types of **Anticodon.**
- t-RNA recognized its place on m - RNA with the help of Anticodon.
- The anticodon of t - RNA recognises its complimentary sequence on m-RNA. This complimentary sequence is known as condon.

(3) **DHU Loop :**

- It is also known as **Amino - acyl synthetase recognition loop.** Amino - acyl systhetase is a specific type of enzyme. The function of this enzyme is to activate a specific type of amino acid. After activtion this enzyme attaches the aminoacid to the 3' end of of t - RNA.
- There are 20 types of enzymes for 20 types aminoacids.
- The function of DHU loop is to recognize this specific Aminoacyl synthetase enzyme.

(3) **messengar RNA (m - RNA) :**

- The m - RNA is 1 - 5% of the cell's total RNA.

  Discovery : Messenger RNA was discovered by Huxly, Volin and Astrachan. The name m-RNA was given by **Jacob** and **Monad.**
- The m-RNA is produced by genetic DNA is the nucleus. This process is known as Transcription.