Genetic Materials

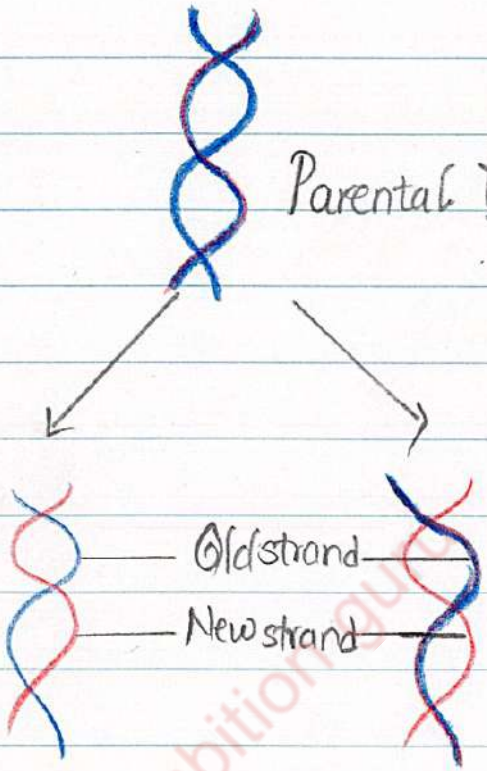
1. "By semi-conservation method, DNA replication to form the same type of two identical DNA in S-sub phase of interphase." Explain the mechanism involved during this process with various enzymes and necessary diagrams. (8 marks) (2080)

OR

Replication of DNA is one of the genetical process in organisms. How is DNA replicated? Briefly describe the mechanism of semi-conservative method of replication that forms daughter DNAs with necessary diagrams.

- DNA (Deoxyribonucleic acid):
- A chemical compound which is responsible to transmit the genetic characters from one generation to another one.
- Acts as a genetic material in all kinds of living beings including some viruses.

- Semi-conservative method of replication:
- Two daughter DNA are formed from parental DNA.
- Each daughter DNA bears one strand conserved from parental DNA and remaining half is newly synthesized.



Mechanism of Semi-conservative mode of DNA replication:

i. Origin of replication:

- DNA consists of many replications unit called replicons or ori-site from where replication begins.

- Formed by breakage (nicking) of phosphodiester bond present between sugar and phosphate without removal of nucleotides.
- Nicking is caused by enzyme endonuclease.

ii. Activation of deoxyribonucleotides:

- Inactive deoxyribonucleotide or deoxyribonucleoside monophosphate (dNMPs) present in nucleoplasm reacts with ATP.
- Then changes into active deoxyribonucleotide/deoxyribonucleoside triphosphate with the help of enzymes phosphorylase.
- Process is called phosphorylation.

$dNMP + ATP \xrightarrow{\text{Phosphorylase}} dNTP + H_3PO_4$

$dAMP + ATP \xrightarrow{\text{Phosphorylase}} dATP + H_3PO_4$

and so on. (Mononucleic acid changes into trinucleic acid)

iii. Unwinding of DNA helix:

- Occurs in the presence of enzyme helicase which breaks the hydrogen bond between the nucleotides.
- Unwinding creates coiling tension, due to super ~~coil~~ coiling.
- At the same time another enzyme topoisomerase-I (DNA gyrase) breaks the phosphodiester link in one strand of the helix

and allows the helix to rotate around the unbroken strand.
- Due to unwinding of two DNA strand, a Y-shaped fork is formed called replication fork.
- Two seprated strands are called templates.

iv. Formation of RNA primer:
- Replication guided by RNA primer.
- A small strand of RNA which is synthesized by enzyme primase.
- RNA primer attached on the template DNA at a site called initiation site, from where replication begins.

- Replication always proceed from 5'-3' direction in the new DNA strand.

iv. Synthesis of new complementary strand:

- After the formation of RNA primer, replication starts with the help of enzyme DNA polymerase (Eukaryotes) and DNA polymerase - III (Prokaryotes)
- Before addition of new nucleotide to the chain activated in nucleotideds are deactivated.
- Nucleotide chain formation proceed from the initation site by the addition of new bases.

- Due to base specificity, base of template DNA attracts it's complementary base pair from nucleoplasm.

(A pair with T
and
C pair with G)

- Replication process is biclirectional it proceed in both template DNA in opposite direction.
- Replication is continuous in one strand, thus new strand is formed called leading strand.
- Replication is not continuous in another strand due to which smaller fragment of DNA are formed called Okazaki fragments.
- Okazaki fragments are joined

together with the help of enzyme DNA ligase and another new strand is formed called lagging strand.
- After nucleotide chain formation is completed RNA primer is removed and gap filled by complementary bases

vi. Termination:
- DNA molecule replication is terminated when two replication fork meets.
- But in some specific termination sequence block further replication

vii. Proof reading and DNA repair:
- Sometimes wrong base may

insert during proof reading.
- Activity of DNA polymerase removes the incorrectly paired nucleotide and then insert the correct one.

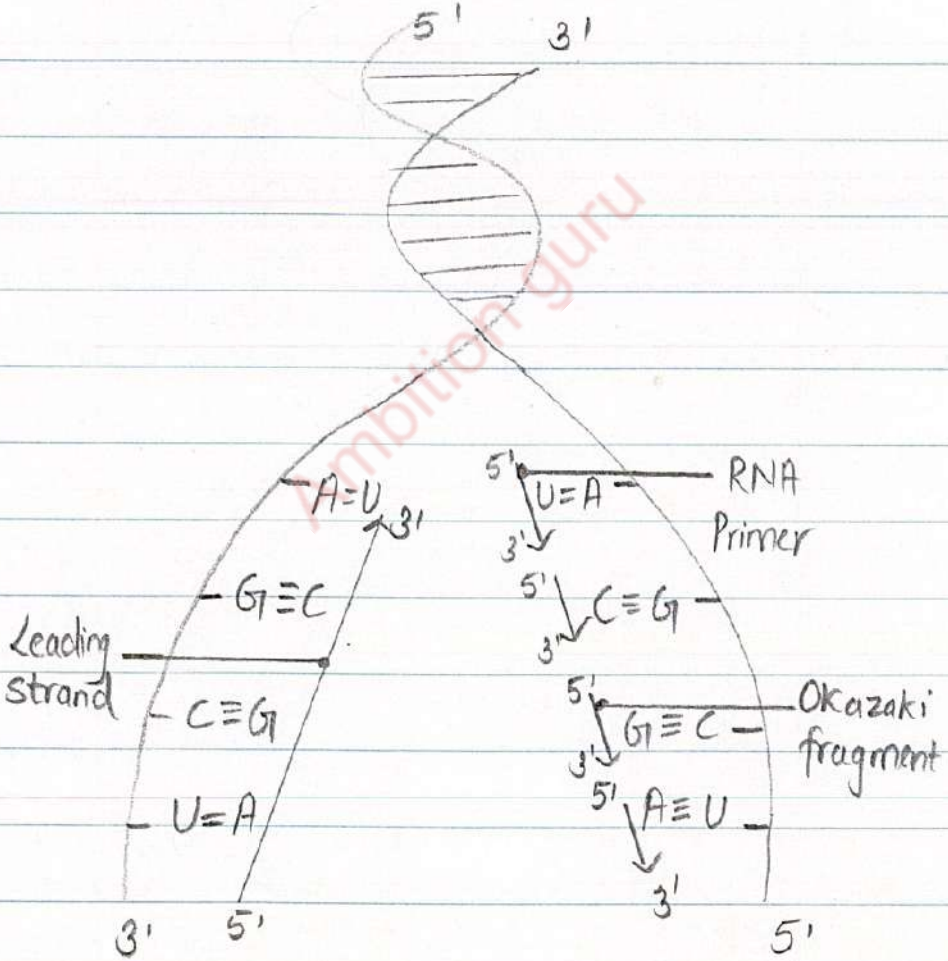


Fig: Replication of DNA

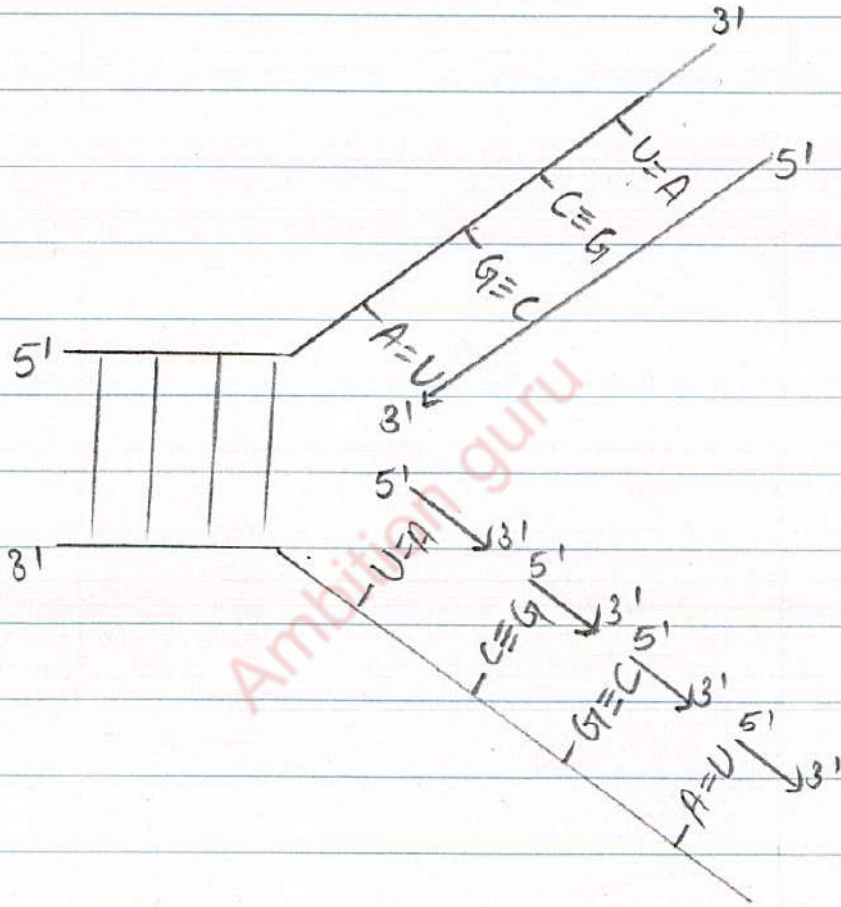


Fig: Semi-Conservative mode of DNA replication

2. What is genetic material? Describe the structure and function of DNA. (8 marks) (2076, 2073)

OR

Describe the double helical structure of Watson and Crick model of DNA. (4 marks) (2077)

-- Genetic material:

- Substance which gets transformed from one generation to next generation to express parental character.
- Should be capable to replicate and inherited to off springs.

• DNA (Deoxyribonucleic acid):

- Found in nucleus, mitochondria and plastid.

- Discovered by Friedrich Miescher 1869.

Structure of DNA:

- Double helix structure consists of two polydeoxyribonucleotide chains (strands) which are twisted around each other on a common axis.
- Each nucleotide is made up of sugar, phosphate and nitrogen base, these nucleotides are linked together by phospho-diester bond.
- Two strands of DNA are antiparallel in direction, one runs in 5' → 3' direction.
- Diameter between these two

strands of double helix is 20°A
- Distance of 1-turn is 34°A and distance between each two nitrogen base pair is 3.4°A.
- Consists of 10 base pairs in each complete turn.
- Two strands are held together by nitrogen bond between complementary base pairs.
i.e

$$A = T \text{ (Double bond)}$$

and

$$C \equiv G \text{ (Triple bond)}$$

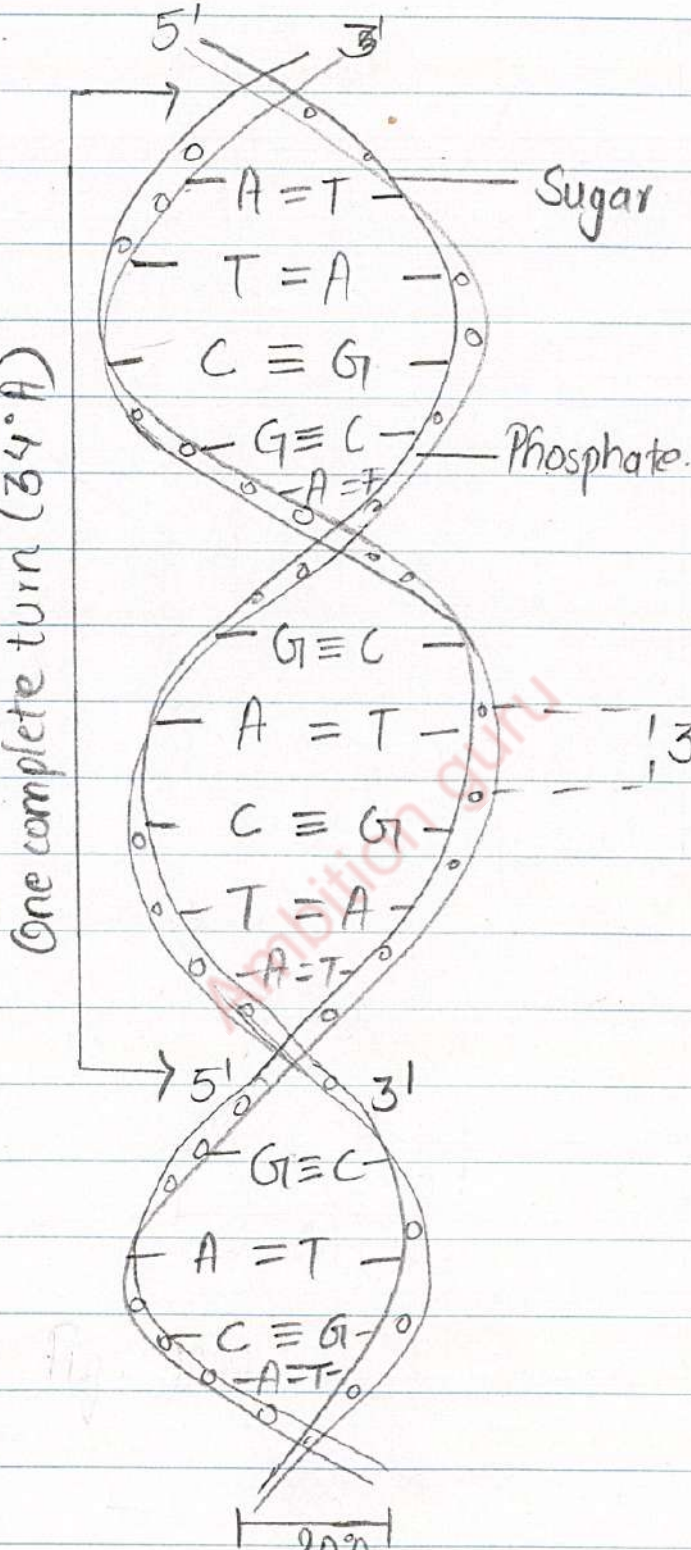

5'
3'
A = T
T = A
C ≡ G
G ≡ C
A = T
Sugar
Phosphate.
One complete turn (34°A)
3.4°A
5'
3'
20°A.

Fig: DNA.

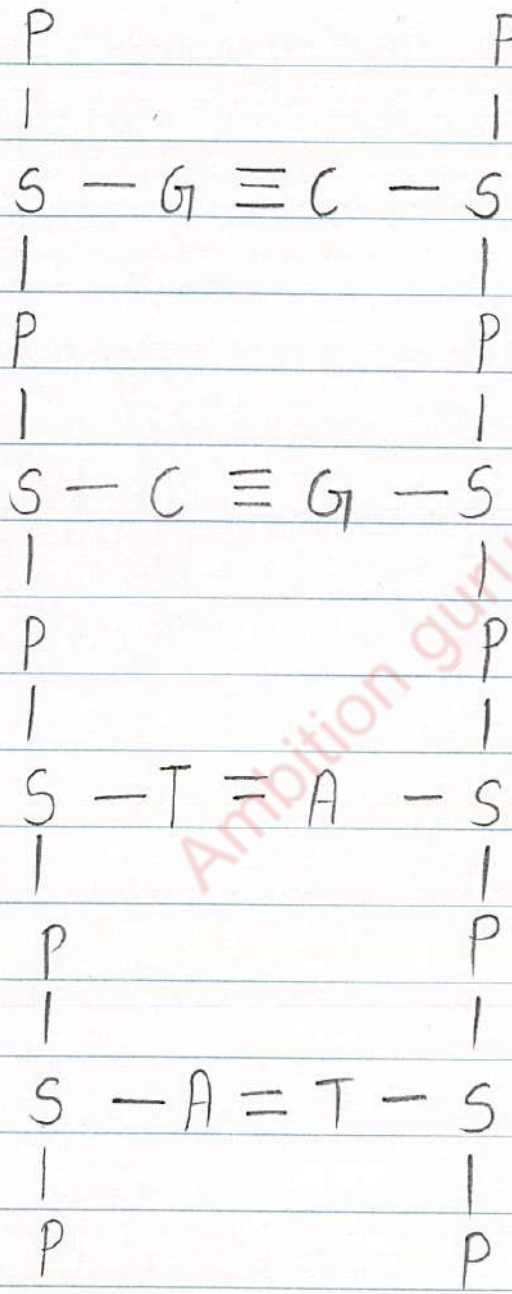


Fig: Chemical Structure of DNA

Function of DNA:

i) A hereditary material, transfer genetic information from parents to off-springs.

ii) Controls the metabolic activity of the cell by forming the necessary enzymatic protein.

iii) Controls all the biological activity of life so called Blue print of life

iv) Enables the cell to maintain, grow and divides by directing the synthesis of structural protein.

v) Plays major role in protein synthesis.

vi) Synthesize RNA by the process of transcription.

3. Describe the structure and function of RNA with its types. (8 marks)

- RNA (Ribo-nucleic acid):
- Found in nucleolus, ribosome, mitochondria, chloroplast and in cytoplasm.
- Found as a genetic material in some viruses such as animal viruses and bacterio-phage.

Structure:
- Single stranded structure.
- Consists of poly-ribonucleotides.
- Nitrogen base are: Adenine, Guanine, Cytosine and Uracil.

- Nucleotides joined together by phosphodiester bond.

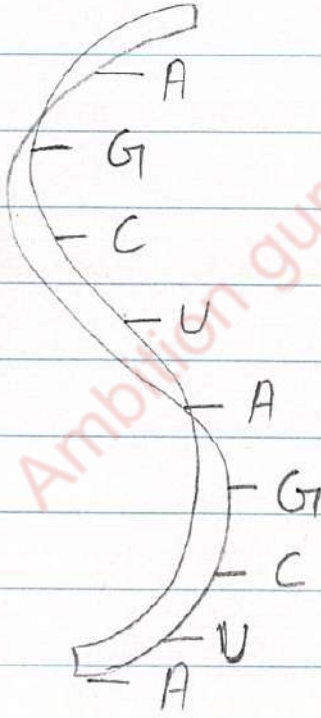


Fig: RNA

Types:

1). Messenger RNA (mRNA):

- Synthesized in nucleus as heterogeneous nuclear RNA and has linear structure.
- Heterogeneous in size and stability (unstable).
- Carries genetic information coded in DNA in the form of codons (triplet) to the ribosome where it is translated into proteins.
- Comprises 5-10% of total RNA.

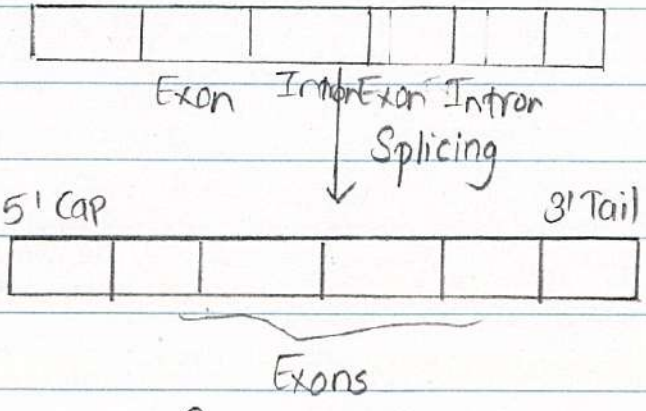


Fig: mRNA

ii. Ribosomal RNA (r-RNA):

- Most abundant and stable type of RNA.
- Comprise 70-80% of total RNA.
- Synthesized from DNA in a nucleolar organizing region of chromosome and finally diffuse into the cytoplasm and binds with protein molecule to form ribosome.
- Also insoluble RNA.

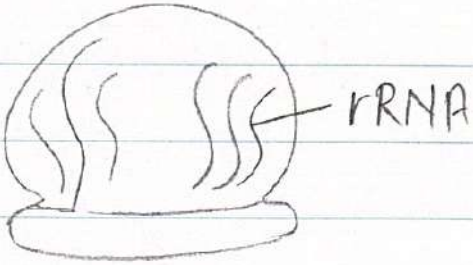


Fig: rRNA

iii. Transfer RNA (tRNA):

- Smallest RNA, also known as soluble RNA.
- Comprises about 10-15% of total RNA.
- Formed in the same way as mRNA formed in RNA.
- 1-tRNA carries only one amino acid.
- Gets coil over itself to form a shaped like clover-leaf.

Loop I- Dihydrouridine (DHU) loop.

Loop II- Anticodon loop

Loop III- TΨC ~~loop~~ Extra arm

Loop IV- TΨC loop, where Ψ = pseudouridine.

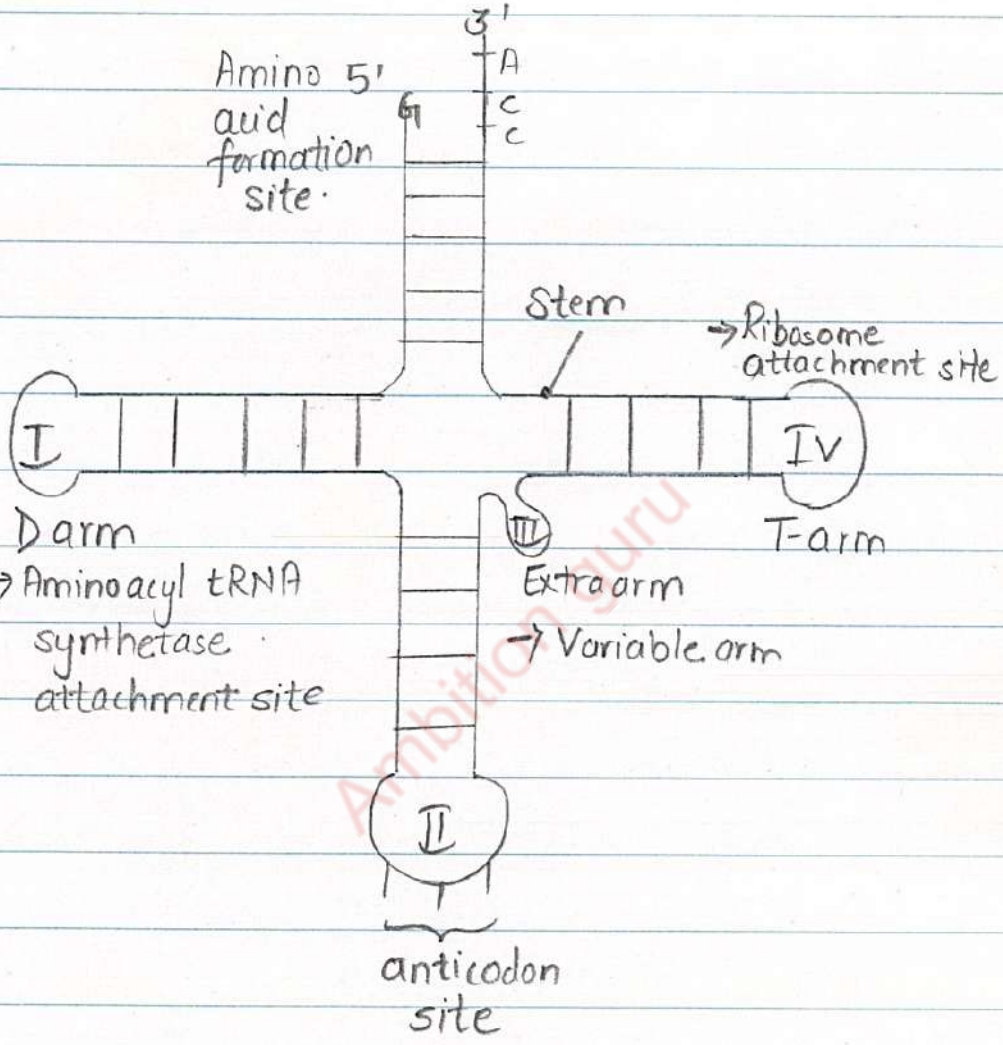


Fig: Clover Leaf model of tRNA.

Function of RNA:

i) Found as a genetic material in some viruses ~~with~~ such as animal viruses and bacteriophage.

ii) Plays an important role in protein synthesis.

iii) rRNA binds protein molecule and give rise to ribosome.

iv) t-RNA picks up specific amino acids from cytoplasm and transports them to ribosome where protein is to be synthesized.

4. Difference between DNA and RNA. (4 marks)

DNA	RNA
i) Double stranded structure.	i) Single stranded structure.
ii) Pentose sugar is deoxyribose.	ii) Pentose sugar is ribose.
iii) Nitrogen base are Adenine, Guanine, Cytosine and Thymine.	iii) Nitrogen base are Adenine, Guanine, Cytosine and Uracil.
iv) Carries genetic information from parents to their offspring.	iv) Helps in protein synthesis.

5. What is gene code? Write the characteristics of genetic code. (4 marks) (2080)

-Def^{n}: Group of three nucleotides that specify or code for one amino acid.

Characteristics of Genetic code:

i) The code is triplet:
- Code which coded amino acid should be triplet in nature.
- For any amino acid it is necessary to have triplet codon.
- 64 (4x4x4) triplet codon are possible.

i.e. enough to code 20 amino acids.

ii) Code is degenerate:
- More than 1-codon may specify the same amino acid.
- Since, 61 codons to be coded for 20 amino acids, codon is degenerate.

iii) Code is non-overlapping:
- Same nitrogen base letters are not used for two different codons.
- Genetic code always read from 5' ⟶ 3' point as a continuous base sequence.

iv) Code is comma less:
- No punctuation between the adjacent codons.
i.e. after one codon another codon will automatically come without any punctuation.

v) Code is universal:
- Genetic code is applicable universally.
- Same genetic code specify same amino acid in all living organism from a virus to a plant or human beings.

vi) Code is non-ambiguous:
- No ambiguity about a particular codon.

- Particular codon will always code for the same amino acid.
- 1- Exception: GGA is the code for glycine as well as glutamine.