PUC Ist year-Semester – 2

Unit II. Chemical constituents of living cells

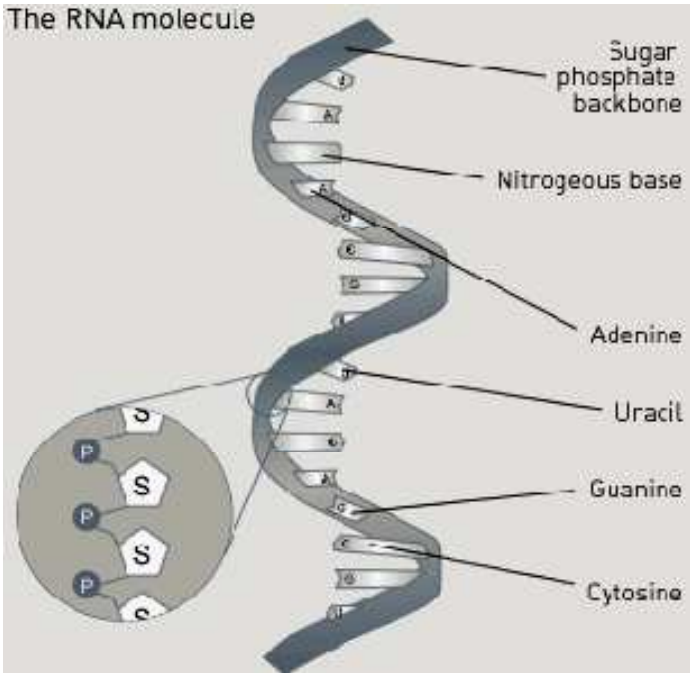
Module No 13. RNA – Structure and Function

Introduction:

Ribonucleic acid (RNA) is the predominant nucleic acid in the cytoplasm, but all cytoplasmic RNA is of nuclear origin. In the nucleus it is present in the nucleolus, nucleoplasm and chromatin and in the cytoplasm RNA is the main component of the ribosomes. and also found in plastids and mitochondria in traces.

RNA plays an important role in protein synthesis and is non – genetic.

However, in many plant viruses (TMV) it acts as the genetic material. DNA contains all the information but RNA does all the work. There are several important differences between DNA and RNA. The first is the sugar of DNA is deoxyribose, where as RNA contains ribose. The second difference is that RNA contains no thymine but instead contains Uracil, and the third difference is that RNA is not a regular double helix.



Structure:

RNA is a polymer, the monomer units of which are ribonucleoside mono phosphates. RNA is made up of a single polynucleotide strand, where in nucleotide units linked by 3^1-5^1 phosphate diester bonds. The nucleotides of RNA comprise of three components as in DNA, the phosphate group, and ribose sugar ($C_5H_{10}O_5$) and nitrogen bases. The nitrogen bases are Adenine, Guanine, Cytosine and Uracil. These nitrogen bases do not show complimentarity, hence there is no 1:1 ratio between purines and pyrimidines as in DNA. This suggest that RNA does not possess a regular hydrogen bonded structure.

Although each RNA molecule has only a single polynucleotide chain, it is not a smooth linear structure. However, the RNA strand may be twisted around itself to produce DNA-like helices at several places. In the region of helix formation, the bases are hydrogen bonded i.e., adenine pairing with uracil, and guanine with cytosine. Non helical region of RNA contain many non bonded bases. RNA is synthesized within the nucleus by using only one strand of DNA as template.

Types of RNA:

There are two types of RNA are known namely genetic RNA and non-genetic RNA.

I. **Genetic RNA:** Genetic RNA is present in the plant viruses when DNA is absent. In many bacteriophases also, genetic material is RNA. This RNA controls the genetic activities. It may be single stranded or double stranded. When RNA is double stranded it generally follows the same rules of base pairing as in case of DNA.

II. Non-genetic RNA: This RNA does not serve as a genetic material. This non-genetic RNA is synthesized on DNA template and is of following five types.

a) Messenger RNA (m RNA)
b) Transfer RNA (t RNA)
c) Ribosomal RNA (r RNA)
d) Small, nuclear RNA (sn RNA)
e) Heterogeneous nuclear RNA (hn RNA)

a) Messenger RNA (m RNA):

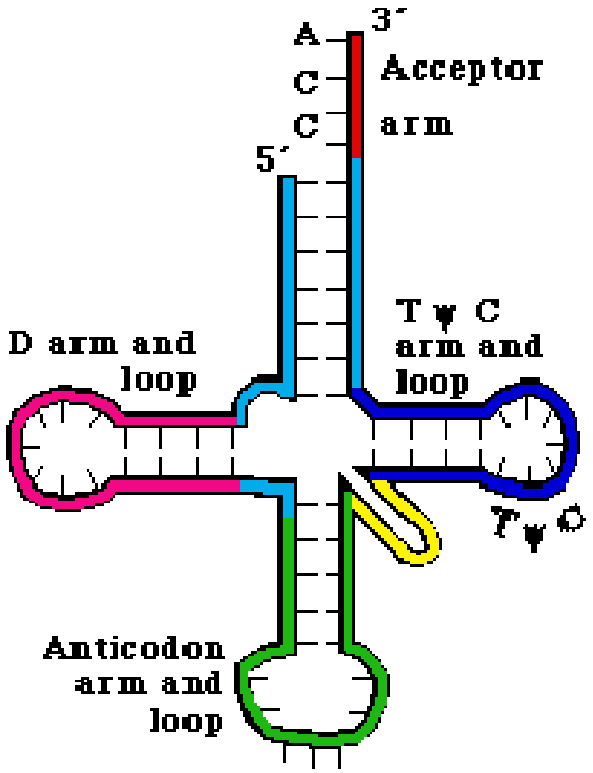
Messenger RNA molecules are synthesized in the nucleus by DNA. It consists of only 3 to 5% of the total cellular RNA. The sequence of bases in m RNA is determined by complementary sequence on DNA. Messenger RNA carries the information specifying a particular protein product. Each three m RNA bases in a row forms a genetic code word or codon, that specifies a particular amino acid. Thus mRNA acts as template for the translation of the DNA code into specific protein.

b) Transfer RNA (t RNA) or Soluble RNA (s RNA):

It constitutes about 10-20% of the total RNA of the cell, it is a relatively small RNA made up of 73-93 nucleotides. These RNA molecules work as adaptor molecules for carrying amino acid molecules to the site of protein synthesis. The t RNA molecule bends on itself and forms as a double stranded **clover leaf model**. The nitrogen bases of the two strands may be paired similar to that of DNA double helix. There are at least 20 species of t RNAs corresponding to 20 amino acids present in protein structure.

The t RNA contains mainly four arms, each arm contains a base paired stem.

1. **The acceptor arm:** The amino acid is attached to this arm.
2. **The anticodon arm:** This arm contain three unpaired bases forming anticodon and is responsible for the recognition of triplet codon of mRNA.
3. **The D-arm:** It is involved in binding to the specific activating enzyme (amino acyl synthetase).
4. **The T φ C arm or ribosomal binding arm:** Binds to ribosomal surface during proteins synthesis.



Transfer RNA helps in transportation of amino acids from cytoplasm to the surface of larger sub units of ribosomes during protein synthesis.

c) Ribosomal RNA (r RNA):

Ribosomal RNA, as the name suggests, is found in the ribosomes. It comprises about 80% of the total RNA of the cell. This type of RNA associates with certain proteins to form a ribosome. A ribosome is a structural support for protein synthesis. Ribosomal RNA play a significant role in the binding of m RNA and t RNA to ribosomes and protein synthesis.

d) Small, nuclear RNA (sn RNA):

The small, nuclear RNA is a metabolically stable RNA molecules found in the nucleus of the cell. It occurs predominantly in ribonucleo protein particles. However, much of this RNA never leaves the nucleus and thus never participates directly in protein synthesis. However, they are involved in processing of hn RNA into m RNA.

e) Hetero geneous nuclear RNA (hn RNA):

It is found in nucleus. Heterogeneous nuclear RNA refers collectively to the variety of RNAs which include primary transcripts, partially processed RNAs and sn RNA. The term hn RNA is often used just for the unprocessed primary transcripts.

Function

1 It is an adapter molecule in protein synthesis and a structural molecule in cellular organelles.
2 RNA can function as a carrier of genetic information, a catalyst of biochemical reactions.
3 One of the primary functions of RNA is to facilitate the translation of DNA into protein.

Check points

- When ribonucleotides serve as monomers, the resulting polymer is ribonucleic acid, or RNA.

- RNA is normally single-stranded (although some viruses contain doublestranded
- Many bases in RNA molecules such as ribosomal RNA and transfer RNA are chemically modified after polymerization, a process which makes these molecules more stable.
- RNA consists of a "backbone" of alternating units of phosphate and ribose sugar. Purine or pyrimidine bases are attached to the 5-C ribose sugar.
- The only effective pairs in RNA are Adenine with Uracil (A-U pairs) and Guanine with Cytosine (G-C pairs).
- tRNA, mRNA, rRNA, hnRNA and snRNA are different types of RNA. Each type of RNA has a different role in various cellular processes.
- RNA acts as a messenger between DNA and the protein synthesis complexes known as ribosomes.

MCQ

1. RNA doesn’t have

   A. Thymine

   B. Uracil

   C. Guanine

   D. Cytosine

2. Which of the following is NOT true?

   A. RNA contains the bases adenine, uracil, guanine and cytocine

   B. RNA synthesis proceeds in a 5’ to 3’ direction

   C. RNA is proof read during synthesis

   D. RNA can be synthesised without a DNA template

3. For the protein synthesis, which type of RNA molecule is essential?
   A. m-RNA
   B. r-RNA
   C. t-RNA
   D. All the above.
4. Which of the following distinguishes RNA from DNA?
   A. Presence of phosphate in the nucleotide
   B. Formation of phosphodiester bonds in the strands
   C. Presence of hydrogen bonds between two helical strands
   D. Presence of adenine, uracil, guanine and cytosine as bases.

5. A strand of DNA with the sequence AACGTAACG is transcribed. What is the sequence of the mRNA molecule synthesized?

   A. AACGTAACG
   B. UUGCAUUGC
   C. AACGUAACG
   D. **TTGCATTGC**

6. Which of the following is found only in RNA

   A. Adenine
   B. Uracil
   C. Cytosine
   D. Guanine

7. RNA that exhibits clover leaf model

   A. m-RNA

B. t-RNA

C. r-RNA

D. sn-RNA

8. Function of t-RNA molecules

A. Carries the information specifying a particular protein product.

B. Carrying amino acid molecules to the site of protein synthesis

C. Binding m-RNA to Ribosomes.

D. Processing of hnRNA into m-RNA

9. RNA molecule is composed of

A. Pentose sugar, phosphoric acid, pyrimidines

B. Pentose sugar, phosphoric acid, pyrimidines and Purines

C. Pentose sugar, phosphoric acid

D. Pentose sugar, pyrimidines and Purines

Short answer questions

1 What are the components of RNA?

2 What is the location of RNA in a cell?

3 What is the role of RNA?

4 Write about the base pairing in RNA.

5 Name different types of RNA.

6 Give an account of (a) hn RNA and (b) sn RNA

7 Describe briefly the m-RNA and its role in protein Synthesis.

8 What is the function of t-RNA?

9 What is the difference between base pairing of DNA and RNA?

10 Explain the structure of t-RNA?

Long answer questions

1) Give detailed account on the structure of RNA.

2) What are the types of RNA? Mention about their individual functions?