1.2.6 RNA

DNA contains all the information needed to maintain a cell's processes, but these precious blueprints never leave the protected nucleus. How, then, is all this data transmitted to the body of the cell itself where it may be put to use? The answer: by way of RNA.

RNA molecules play essential roles in the transfer of genetic information during protein synthesis and in the control of gene expression. The diverse functions of RNA molecules in living organisms also include the enzymatic activity of ribozymes and the storage of genetic information in RNA viruses and viroids. So, ribonucleic acid may be genetic or non genetic, catalytic or non-catalytic and coding (mRNA) or noncoding (like tRNA, rRNA).

Thermodynamic stability of RNA structure

Primary structure of RNA refers to the sequence of nucleotides. Secondary structure in RNA is dominated by Watson-Crick base pairing. This fundamental interaction between bases leads to the formation of double-helical structures of varying length. In RNA, double-helical tracts are generally short. RNA double helices adopt the A-form structure, which differs significantly from the canonical B-form adopted by DNA double helices. RNA secondary structure is generally more stable than its tertiary structure. Thus, formation of the secondary structure dominates the process of RNA folding. RNA tertiary structure forms through relatively weak interactions between preformed secondary structure elements.

Types of RNA

Within a given cell, RNA molecules are found in multiple copies and in multiple forms. Major RNA classes are mRNA, rRNA, tRNA, snRNA, SnoRNA, miRNA, XIST, scRNA, siRNA, tmRNA and telomerase RNA. Features of few major forms of RNA present in prokaryotic and eukaryotic cells are given below.

mRNA

mRNA (messenger RNA) carries the genetic information copied from DNA in the form of a series of three-base code words, each of which specifies a particular amino acid. Most of the eukaryotic mRNAs represent only a single gene: they are **monocistronic**. mRNAs carry sequences coding for several proteins are called **polycistronic**. In these cases, a single mRNA is transcribed from a group of adjacent genes. Most of the prokaryotic mRNA are polycistronic.

All mRNAs contain two types of regions. The coding region consists of a series of codons starting with an AUG and ending with a termination codon. But the mRNA is always longer than the coding region, extra regions are present at both ends. The untranslated region at the 5' end is described as the *leader* and untranslated region at the 3' end is called the *trailer*. A polycistronic mRNA also contain *intercistronic* regions. They vary greatly in size. They may be as long as 30 nucleotides. Eukaryotic mRNA molecules often require extensive processing and transport, while prokaryotic molecules do not.

tRNA

tRNA is a small, well-characterized RNA molecules with a key role in protein biosynthesis. Transfer RNA also known as adaptor RNA. The concept of an adaptor to provide the interface between nucleic acid language and protein language was introduced by Crick in 1955. tRNAs also participate in nonprotein synthetic processes such as acts as a primer during reverse transcription in retrovirus life cycles.

Structural properties

tRNA is a single RNA chain of 75-93 nucleotides, present in the cytosol and organelles of all living cells. Holley and his co-workers determined the first tRNA sequence in 1965. Dictated by their primary sequence, tRNA fold into cloverleaf-like secondary structures with well-defined stems and loops that make up the acceptor arm, D arm and loop, anticodon arm and loop, and the T-arm and loop. Regardless of the length of the tRNA, the numbering of conserved nucleotides remains constant.

The acceptor stem always has 7 base pairs and 4 single-stranded nucleotides, including an absolutely conserved CCA sequence. The D stem and loop are of variable length, whereas the anticodon stem has 5 nucleotides and the anticodon loop has 7 nucleotides. The variable region usually has 4-5 nucleotides but can contain up to 24 nucleotides.

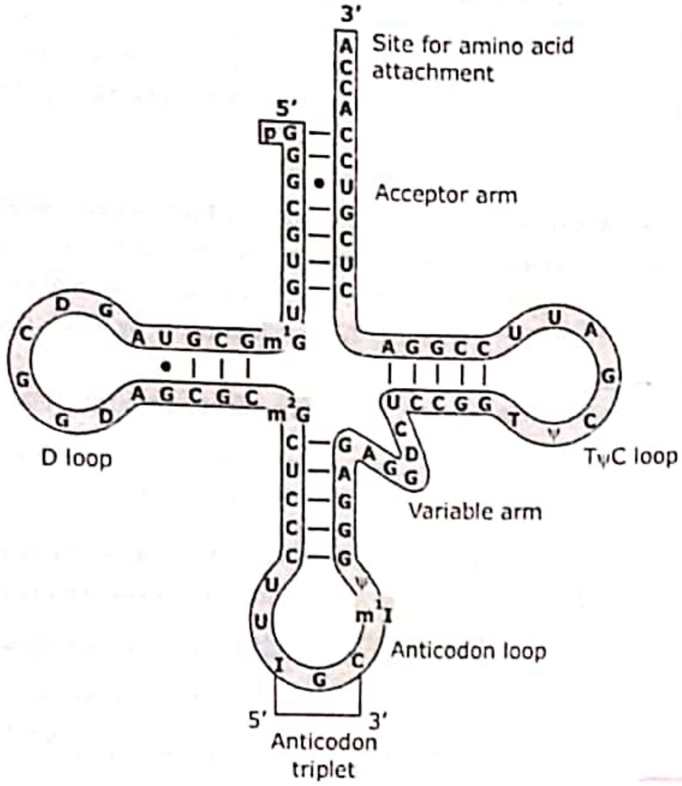

Figure : 1.35
Nucleotide sequence of yeast $tRNA^{Ala}$. This structure was deduced in 1965 by Robert W. Holley and his colleagues; it is shown in the cloverleaf conformation in which intrastrand base pairing is maximal. The following symbols are used for the modified nucleotides : ψ, pseudouridine; I, inosine; T, ribothymidine; D-5, 6-dihydrouridine.

Finally, the T-stem always has 5 base pairs and the T-loop has 7 nucleotides. All tRNAs share the same secondary structure. tRNA are classified according to the length of their variable region, which can be 4 or 5 nucleotides (class I tRNA) or 10-24 nucleotides (class II tRNA). A new class II tRNA, discovered more recently in many organisms, serves as the adaptor for *selenocysteine*, the 21st amino acid. tRNAs are thought to fold into the L-shaped 3D structures necessary to fulfill their functions. All tRNAs also share the same L-shaped three-dimensional structure. In each cell or organelle, there are 20 families of tRNA, one per each amino acid. Isoacceptor tRNAs belong to the same family and are charged with the same amino acid during protein synthesis.