Structures and types of RNA

In general, RNA is similar to a simple DNA structure. 60% of RNA is found in ribosomes as rRNA. RNA functions during protein synthesis. (Proteins are formed with combination of amino acids with the removal of a H_2O molecule). Combination of these amino acids is not coincidental and is administered under the control of DNA and with the help of enzymes and RNA.

4 types of nucleotides are present in DNA and RNA, i.e., 4 codes are present. Each nucleotide (code) synthesizes a certain amino acid, so only 4 types of amino acids can be synthesized. In order to synthesize a protein molecule containing 20 amino acids, we need at least 20 codes. Crick and his friends determined during their studies on bacteriophages that each amino acid is coded with three bases. The triple base coding an amino acid is called a codon.

By using these codons, **64** codes can be obtained. The amino acids coded by **61** different codons were determined. 3 of them do not code an amino acid (**UAA**, **UAG** and **UGA**) and correspond to some signals during protein synthesis. These are called **stop codons**. AUG is the start codon. Only tryptophan and methionine are determined with a single codon, the other amino acids have more than one codon.

RNA types:

Humans have a single type of DNA, however there are more types of RNA:

- Ribosomal RNA (rRNA)
- Transfer RNA (tRNA)
- Messenger RNA (mRNA)

These 3 RNA types have functions in the **transcription** and **translation** of the genetic information, that's why RNA is generally considered to be divided into 3 types.

- Ribosomal RNA (rRNA): rRNA consists of the 60% of the ribosome in eukaryotes and is located in the ribosomal subunits.
- Transfer RNA (tRNA): Selects the amino acids and transfers them. Consists of 10% of the whole cellular RNA. It is found in the cytoplasm. It catches the amino acids and places them into the appropriate placed on the mRNA.
- Messenger RNA (mRNA): Transferring of the genetic information found in the DNA to the mRNA molecule is called **transcription**, and transferring of this information to protein molecule from mRNA and the synthesis of protein is called **translation**. This whole concept is called **central dogma**.

According to central dogma, instead of coding the protein directly, DNA produces a master blueprint that contains the genetic information of an organism and uses RNA as an intermediary molecule. Transferring of genetic material from DNA to RNA is called **transcription**. In this process RNA polimerase enzyme adds the corresponding RNA base to each base of DNA. The resulting RNA is called mRNA and it is read by the protein synthesis machine called ribosome and corresponding protein is formed. This process is called **translation.** The genetic information found in mRNA is converted into triple bases.

First of all, in order for protein synthesis to be performed, the below factors have to be present:

- DNA
- Activating enzymes
- Three types of RNA(mRNA, tRNA, rRNA)
- Ribosomes
- Some protein factors
- ATP and GTP molecules
- Mg^{+2} ions

Some stages can be identified in protein synthesis.

- First, a RNA (mRNA) copy of the information (DNA) that codes the protein that is to be synthesized has to be made.
- mRNA takes the message to the ribosomes where protein synthesis will be performed.
- Protein synthesis system found on ribosomes starts reading the message carried by the mRNA as tripe base groups coding each amino acid.
- Protein chain proceeds from the NH_2 end of the polypeptide chain to the COOH end by attaching an amino acid at each step.

The codons in the mRNA molecule recognized by the anticodons found at tRNA per rules of base pairing and appropriate amino acids are brought to the protein synthesis system with their specific tRNAs. This process continues till all message is read, in other words till the protein synthesis is complete.

When the last amino acid at the COOH end of the protein enters into the structure of the polypeptide, this completed chain leaves the ribosome. As a result of electrostatic relations between the side groups of the amino acids forming the primary structure, the protein chain makes a curve and gains its three dimensional active protein configuration.

Before protein synthesis starts, amino acids have to be activated first. Activation process is catalyzed by **amino acyl tRNA synthetase** enzymes. In order to produce protein molecules from amino acids, these amino acids first have to bind to the tRNA molecule, and for this bonding to take place, amino acid and tRNA have to recognize each other. This recognition is carried out by an enzyme that both recognized the tRNA and the enzyme. This enzyme generally has a molecular weight of 100.000 dalton and has three specific bonding sites for 3 elements.

The amino acid that has to be activated binds to one of these sites, ATP binds to the second and tRNA specific for the activated amino acids binds to the third site. **Aminoacyl tRNA synthetase** enzyme is very important since if a wrong amino acid is attached to the tRNA, this enzyme recognizes this error and the amino acid is hydrolyzed and removed from the 3′ end of the amino acid. **Mg^{+2}** and ATP are also used in the activation.

Following the activation of amino acids, protein synthesis is carried out in a very similar 3-step pathway in both prokaryotes and eukaryotes:

1) Initiation

2) Elongation

3) Termination

1) Initiation of protein synthesis (Translation)

Converting the genetic information written as RNA bases (Adenine, Guanine, Cytosine, Urasil) into an amino acid sequence is called **translation.** Activated amino acids bind with tRNA molecule with the help of aminoacyl synthetase enzyme. The amino ascid attaches itself with its carboxyl group to the 3'-OH group that is found in the adenine nucleotide that is attached to tRNA molecule. Binding of the amino acid to the tRNA molecule is called **loading**. Translation starts in both prokaryotes and eukaryotes with the starting codon, **AUG** (this codon also encodes the amino acid methionine). Therefore, in every synthesized amino acid, methionin has to be present.

2) Elongation of the polypeptide chain

After initiation, it is time for the elongation of the polypeptide chain (translation). First aminoacyl-tRNA is attached to the ribosome. Then, a H bond is formed between the enzyme and AUG. The formation of tRNA-codon complex effects the codon found in mRNA and a complex is formed with an appropriate mRNA-anticodon. After this, ribosome moves in the direction 5′→3′ for the elongation of the polypeptide chain and new amino acids are added to the polypeptide chain.

With dehydration, the carboxyl group of an amino acids binds with the amine group of another amino acid, i.e. a peptide bond is formed and one molecule of water is released. After the formation of peptide bond, tRNA (unloaded) leaves the ribosome and enters into the cytoplasm. Elongation of the protein chain stops till the stop codon is encountered (**stop-UAG**).

Translation of mRNA can be performed simultaneously with numerous ribosomes both in prokaryotes and in eukaryotes. The complex between these ribosomes is called **polyribosome** or **polysome**. An average of 8-10 ribosomes can form a polysome complex to synthesize proteins at the same time, thus a considerable amount of proteins are synthesized.

Termination of polypeptide chain (termination of translation)

Elongation of the protein chain continues till the last codon determined by the mRNA is reached, and protein synthesis stops with the stop codon.

Stop codons in prokaryotes and eukaryotes are **UAA**, **UAG** and **UGA**. In order for ribosomes to recognize these stop codons, they need some factors called **termination factors** or **release factors**. These factors also have protein structure and they recognize the stop codons and termination process starts.

In summary, activated amino acids are arranged according to a certain order per the codons found in mRNA from the NH_2 end of the polypeptide chain that is being synthesized to the COOH end. When the ribosome comes to the stop codon on mRNA, protein synthesis ends. Following this, unloaded tRNA leaves the ribosome and ribosomes subunits separate from each other until new protein synthesis starts.

After this stage, primary structure (a a straight line) and perhaps the secondary structure (spiral) of the protein is completed.

Proteins attain their secondary, tertiary and quaternary structures according to their way of syntheses in the free ribosomes or in the ribosomes that are found on endoplasmic reticulum and mature. Then they are carried to different parts of the cell according to their .

Alpha helix or beta helix sheet is folded into a specific 3-dimensional shape. This shape is stabilized by various interactions among the R-groups of the polypeptide.

Proteins synthesized in the free ribosomes found in the cytoplasm are the structural proteins that the cells keeps for itself.

Proteins synthesized in the ribosomes found in endoplasmic reticulum do not function as structural proteins and sent to Golgi first. Then, following maturation they serve as integral proteins of the cell membrane, lysosomal secretion proteins etc.

Proteins have a short life span some proteins are broken down rapidly to their corresponding amino acids, however the need of the body is met with newly manufactured proteins. This process regulates enzyme levels and also prevents abnormal protein accumulation in the body and thus controls tissue growth.

Protein synthesis is a complex process and therefore it is considered to be an insurance against the errors in the transferring of the genetic information found in DNA. Serious problems may arise even if a single amino acid binds to a wrong place since each living being has proteins that are specific to only itself.

And this difference is especially important in transplantation operations. Different proteins are present in the foreign organ of the donor and the body of the acceptor acts as if it has been under attack of the proteins found in the donor organ and tries to defend itself. The cells in the donor organ are killed with the defense system of the acceptor and thus the organ is rejected.

There is one exception to this rule: identical. Since identical twins are born from a single fertilized egg, the proteins that they have are identical. In other words, DNA molecules of these twins are identical, thus organ transplants between them are performed successfully.

Importance of proteins for the cells:

Our cells have many different proteins and these proteins give each living being their individual distinctive features. The main structure of a cell depends on the proteins that it contains. The cell and its membrane have the structure of lipoproteins. Smaller parts of the cell are partially made out of proteins. The fluid part of cytoplasm is also protein.

the most important proteins found in a cell are the enzymes of that cell these enzymes form the basis of many chemical reactions that are seen in a cell.