OPEN ACCESS Freely available online

ISSN: 2471-2663
Clinical & Medical Biochemistry

Short Communication

Mechanisms of Protein Synthesis and their Biological Importance

Tae Min*

Department of Internal Medicine, Hanyang University, Seoul, Korea

DESCRIPTION

Protein synthesis is a fundamental biological process through which cells produce proteins based on genetic instructions encoded in DNA. This complicated mechanism involves several steps that convert genetic information into functional proteins, each playing a vital role in the cell's structure, function and regulation. The process of protein synthesis is divided into transcription, translation and post-translational modifications, all of which work in concert to ensure the accurate production of proteins. Transcription is the first step in the process of translating DNA into functional proteins. DNA, organized into genes, acts as a pattern for protein production. Each gene contains the instructions to produce a specific protein. During transcription, the information within a gene is copied into a messenger RNA (mRNA) molecule. This process starts when RNA polymerase, an enzyme responsible for synthesizing RNA, binds to a specific region of the DNA known as the promoter. This structure initiates gene transcription. RNA polymerase then slows down the DNA double helix and uses one of the strands as a template to synthesize a complementary RNA strand. RNA nucleotides are added one by one, complementary to the DNA template strand. As the RNA polymerase moves along the DNA, the RNA strand extends, forming a single-stranded mRNA molecule that mirrors the gene's coding sequence, except that Uracil (U) replaces Thymine (T) [1].

Once transcription is complete, the mRNA molecule goes through several modifications before it can be translated into a protein. These modifications include the addition of a 5' cap, a modified guanine nucleotide that protects the mRNA from degradation and helps in ribosome acknowledgment and a poly-A tail, a sequence of adenine nucleotides added to the 3' end of the mRNA, which also enhances stability and translation efficiency. Introns, non-coding regions within the mRNA, have been fused out and the remaining exons, which contain the coding sequences, are joined together. The result is a mature mRNA molecule that exits the nucleus and enters the cytoplasm, where translation occurs. Translation is the process by which the mRNA sequence is read to synthesize a protein. This process takes place in the ribosomes, which are the cellular machines responsible for protein synthesis [2]. Ribosomes consist of two subunits, each composed of ribosomal RNA (rRNA) and proteins. The small ribosomal subunit binds to the mRNA molecule at the start codon, which is a specific sequence of three nucleotides that signals the beginning of protein synthesis. The start codon is typically AUG, which codes for the amino acid methionine. The large ribosomal subunit then attaches to the small subunit, forming a functional ribosome.

Translation occurs in three stages-initiation, elongation and termination. During initiation, the ribosome assembles at the start codon of the mRNA. The first tRNA, carrying methionine, binds to the start codon and the ribosome is fully assembled with the large and small subunits in place. The ribosome catalyzes the formation of peptide bonds between adjacent amino acids, extending the polypeptide chain. Each tRNA molecule is released from the ribosome after its amino acid has been added and the process continues until a stop codon is reached [3-6].

Termination occurs when the ribosome reaches a stop codon on the mRNA. Stop codons signal the end of the protein-coding sequence and initiate the release of the newly synthesized polypeptide chain. Release factors, which are proteins that recognize stop codons, bind to the ribosome and cause the dissociation of the ribosomal subunits and the release of the mRNA and polypeptide. The polypeptide chain then undergoes folding and post-translational modifications to achieve its final functional form. Protein folding is an essential step in the synthesis of functional proteins. The linear polypeptide chain must fold into a specific three-dimensional structure to become functional. Proteins form complicated structures that are necessary for their function. Molecular chaperones, which are specialized proteins, assist in the folding process by preventing misfolding and aggregations. Chaperones help proteins achieve their native conformations and can also facilitate the refolding of misfolded proteins. In some cases, proteins undergo additional modifications, such as phosphorylation, glycosylation and separation, which are necessary for their activity, stability and localization [7].

Correspondence to: Tae Min, Department of Internal Medicine, Hanyang University, Seoul, Korea, E-mail: mintae@gmail.com

Received: 28-Aug-2024, Manuscript No. CMBO-24-26875; **Editor assigned:** 30-Aug-2024, PreQC No. CMBO-24-26875 (PQ); **Reviewed:** 13-Sep-2024, QC No. CMBO-24-26875; **Revised:** 20-Sep-2024, Manuscript No. CMBO-24-26875 (R); **Published:** 27-Sep-2024, DOI: 10.35841/2471-2663.24.10.230

Citation: Min T (2024). Mechanisms of Protein Synthesis and their Biological Importance. Clin Med Bio Chem. 10:230.

Protein synthesis control is a complex process that ensures proteins are synthesized in the proper quantities and at the appropriate periods. Gene expression is regulated at multiple levels, including transcriptional regulation, mRNA stability, and translational efficiency. mRNA stability is another regulatory mechanism. The stability of mRNA molecules affects their availability for translation. The addition of the 5' cap and the poly-A end enhances mRNA stability, while sequences in the 3' Untranslated Region (UTR) can influence mRNA degradation. Small RNA molecules, such as microRNAs, can bind to specific mRNAs and promote their degradation or inhibit their translation, further regulating protein synthesis [8,9].

Translational efficiency is also subject to regulation. Factors such as ribosome availability, tRNA supply and the presence of regulatory proteins can impact the rate of translation. For instance, the binding of regulatory proteins to the mRNA can affect ribosome initiation and elongation. Additionally, stress conditions and cellular signals can alter the translation machinery and modulate protein synthesis in response to environmental changes. The entire process from DNA to functional proteins represents the complexity and precision of molecular biology. Each step, from transcription to translation and post-translational modification, involves intricate interactions between various biomolecules and regulatory mechanisms. This coordinated process ensures that genetic information is accurately translated into functional proteins, which are essential for the diverse selection of cellular functions and processes [10].

CONCLUSION

In conclusion, protein synthesis is a set of systematic procedures that turn genetic information from DNA into functional proteins. Transcription converts DNA sequences to mRNA, which is then translated by ribosomes into polypeptide chains. These chains are folded and modified to create active proteins. Protein synthesis control plays an essential role for keeping cells functioning and modifying to changing environments. The amazing complexity of this process emphasizes the complex interaction of molecular components and regulatory mechanisms that maintain the proper creation and function of proteins in healthy cells.

REFERENCES

1. Aoki H, Dekany K, Adams SL, Ganoza MC. The gene encoding the elongation factor P protein is essential for viability and is required for protein synthesis. J Biol Chem. 1997;272(51): 32254-32259.
2. Breaker RR. Riboswitches and translation control. Cold Spring Harb Perspect Biol. 2018;10(11):a032797.
3. Campbell PN, Work TS. Biosynthesis of proteins. Nature. 1953;171(4362):997-1001.
4. Daly MM, Mirsky AE. Formation of protein in the pancreas. J Gen Physiol. 1952;36(2):243.
5. Fan H, Penman S. Regulation of protein synthesis in mammalian cells: II. Inhibition of protein synthesis at the level of initiation during mitosis. J Mol Biol. 1970;50(3):655-670.
6. Goodman HM, Rich A. Mechanism of polyribosome action during protein synthesis. Nature. 1963;199:318-322.
7. Hellen CU. Translation termination and ribosome recycling in eukaryotes. Cold Spring Harb Perspect Biol. 2018;10(10):a032656.
8. Ingolia NT, Hussmann JA, Weissman JS. Ribosome profiling: Global views of translation. Cold Spring Harb Perspect Biol. 2019;11(5):a032698.
9. Kang HA, Hershey JW. Effect of initiation factor eIF-5A depletion on protein synthesis and proliferation of Saccharomyces cerevisiae. J Biol Chem. 1994;269(6):3934-3940.
10. Liu ZY, Jia KT, Li C, Weng SP, Guo CJ, He JG. A truncated Danio rerio PKZ isoform functionally interacts with eIF2α and inhibits protein synthesis. Gene. 2013;527(1):292-300.