OPEN ACCESS Freely available online

Enzyme Engineering

Perspective

The Essential Role of Protein Nucleotide Interactions in Cellular Functions and its Significance

Nishu Tyagi*

Department of Molecular Science, University of New Delhi, New Delhi, India

INTRODUCTION

Proteins are the workhorses of life, carrying out a myriad of essential functions within cells. To perform these functions, proteins often interact with other biomolecules, including nucleotides. Nucleotides, the building blocks of nucleic acids like DNA and RNA, play a crucial role in cellular processes such as energy transfer, signal transduction, and gene expression. In this article, we will delve into the fascinating world of protein-nucleotide interactions, exploring their significance in biology and the diverse functions they enable within cells.

DESCRIPTION

The basics of nucleotides

Before one dive into protein-nucleotide interactions, let's briefly review what nucleotides are. A nucleotide is composed of three fundamental components:

- **Sugar:** Nucleotides contain a five carbon sugar, either Ribose (in RNA) or Deoxyribose (in DNA).
- **Phosphate group:** A phosphate group is attached to the sugar molecule, forming a phosphodiester bond.
- **Nitrogenous base:** There are four nitrogenous bases in DNA (adenine, guanine, cytosine, and thymine) and four in RNA (adenine, guanine, cytosine, and uracil).

Nucleotides serve as the building blocks for the synthesis of nucleic acids and play key roles in energy metabolism and cell signaling.

Protein nucleotide interactions

Proteins are incredibly diverse molecules with a wide array of functions, from enzymes that catalyze chemical reactions to structural components that give cells their shape. To carry out these functions, proteins often need to interact with other molecules. One crucial type of interaction involves the binding of proteins to nucleotides.

These interactions can be categorized into several key roles

- **Enzymatic activity:** Many enzymes require nucleotide cofactors to catalyze specific chemical reactions. For example, (ATP) Adenosine Triphosphate is a common energy currency in cells and serves as a cofactor for numerous enzymes involved in processes like phosphorylation and DNA replication.
- **Signal transduction:** Proteins can bind to nucleotides as part of signal transduction pathways. G proteins, for instance, cycle between (GDP) Guanosine Diphosphate bound (inactive) and (GTP) Glutamic Pyruvic bound (active) states to transmit signals from cell surface receptors to intracellular effectors [1].
- **DNA and RNA binding:** Proteins involved in gene expression, such as transcription factors and RNA polymerases, interact with nucleotide sequences in DNA and RNA to regulate gene transcription and translation.
- **Structural support:** Some proteins, like the tubulin subunits in microtubules, use nucleotides (in this case, GTP) to provide structural stability and dynamicity to cellular components [2].

Key examples of protein nucleotide interactions

- **ATP and enzymes:** Adenosine Triphosphate (ATP) is a nucleotide that serves as the primary energy currency of the cell. Many enzymes, such as kinases, utilize ATP as a substrate to transfer phosphate groups, facilitating various cellular processes, including signal transduction and metabolic reactions [3].
- **GTP and G proteins:** Guanosine Triphosphate (GTP) is essential for the function of G-proteins, which play a central role in transmitting signals from cell surface receptors to intracellular effectors. GTP binding activates G-proteins, while GTP hydrolysis inactivates them [4].
- **DNA binding proteins:** Transcription factors are proteins that regulate gene expression by binding to specific DNA sequences. They often have domains that recognize and bind to specific nucleotide sequences, allowing them to modulate gene transcription [5].

Correspondence to: Nishu Tyagi, Department of Molecular Science, University of New Delhi, New Delhi, India; E-mail: nishu_tyagi@iedu.com

Received: 19-Sep-2023, Manuscript No. EEG-23-27030; **Editor assigned:** 21-Sep-2023, PreQC No. EEG-23-27030 (PQ); **Reviewed:** 05-Oct-2023, QC No. EEG-23-27030; **Revised:** 16-Sep-2024, Manuscript No. EEG-23-27030 (R); **Published:** 23-Sep-2024, DOI: 10.35248/2329-6674.24.13.250

Citation: Tyagi N (2024) The Essential Role of Protein Nucleotide Interactions in Cellular Functions and its Significance. Enz Eng. 13:250.

- **RNA polymerases:** RNA polymerases, the enzymes responsible for synthesizing RNA from DNA templates, use Nucleoside Triphosphates (NTPs) as substrates. The selection of the appropriate NTPs is crucial for accurate transcription [6].
- Structural proteins: Tubulin, a protein that makes up microtubules, binds to and hydrolyzes GTP to control microtubule polymerization and depolymerization. This dynamic behavior is critical for processes like cell division and intracellular transport [7].

Significance of protein nucleotide interactions

Protein-nucleotide interactions are fundamental to the proper functioning of cells. They are involved in various essential processes, including:

- **Energy transfer:** Nucleotide-based cofactors like ATP and GTP are central to energy transfer and the regulation of metabolic pathways. They provide the necessary energy for cellular activities such as muscle contraction and active transport [8].
- **Cellular signalling:** GTP bound G proteins are key players in cellular signaling, transmitting extracellular signals to intracellular effectors, ultimately leading to specific cellular responses [9].
- **Gene expression:** Proteins that interact with nucleotide sequences in DNA and RNA control gene expression, determining which genes are turned on or off in response to cellular needs and environmental cues.
- **Cell structure and dynamics:** Nucleotide dependent structural proteins, like tubulin, are critical for maintaining cell shape, supporting intracellular transport, and facilitating processes like cell division.

CONCLUSION

Protein-nucleotide interactions are an essential aspect of cellular biology. They enable a wide range of cellular functions, from energy transfer to gene expression and structural support. Understanding the intricacies of these interactions provides insights into the mechanisms underlying life processes and holds promise for developing novel therapeutic strategies targeting various diseases. As research in this field continues to advance, one can expect to uncover even more intricate details about the role of protein-nucleotide interactions in the complexities of cellular life.

REFERENCES

1. Knaus T, Cariati L, Masman MF, Mutti FG. *In vitro* biocatalytic pathway design: orthogonal network for the quantitative and stereospecific amination of alcohols. Org Biomol Chem. 2017;15(39):8313-8325.
2. Grogan G. Synthesis of chiral amines using redox biocatalysis. Curr Opin Chem Biol. 2018;43:15-22.
3. Zhou Y, Wu S, Li Z. One-pot enantioselective synthesis of d-phenylglycines from racemic mandelic acids, styrenes, or biobased l-phenylalanine *via* cascade biocatalysis. Adv Syn Cat. 2017;359(24):4305-4316.
4. Lukito BR, Sekar BS, Wu S, Li Z. Whole cell-based cascade biotransformation for the production of (S)-Mandelic acid from styrene, L-phenylalanine, glucose, or glycerol. Adv Syn Cat. 2019;361(15):3560-3568.
5. Wang Z, Sekar BS, Li Z. Recent advances in artificial enzyme cascades for the production of value added chemicals. Biores Technol. 2021;323:124551.
6. Yi J, Li Z. Artificial multi-enzyme cascades for natural product synthesis. Curr Opin Biotechnol. 2022;78:102831.
7. See WW, Choo JP, Jung DY, Zhi L. Recent developments in oxidative biocatalytic cascades. Curr Opin Green Sust. 2022;38:100700.
8. Zhou Y, Wu S, Li Z. Cascade biocatalysis for sustainable asymmetric synthesis: from biobased l-phenylalanine to high-value chiral chemicals. Angewandte Chemie. 2016;128(38):11819-11822.
9. Wang Z, Li X, Li Z. Engineering of Cascade Reactions and Alditol Oxidase for High-Yielding Synthesis of (R)-Phenylethanolamine from Styrene, l-Phenylalanine, Glycerol or Glucose. Chem Cat Chem. 2022;14(17):e202200418.