Biochemistry & Physiology: Open Access
ISSN: 2168-9652
Jian, Biochem Physiol 2024, 13:3
Editorial Open Access

Insights into Nucleic Acid Biochemistry: Structure, Function, and Therapeutic Applications

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Abstract

Nucleic acids, DNA and RNA, are fundamental biomolecules that store and transfer genetic information. This article delves into the biochemistry of nucleic acids, elucidating their structural intricacies, functional dynamics, and potential therapeutic applications. It explores the molecular composition and three-dimensional configurations of nucleic acids, emphasizing the critical roles of nucleotides and hydrogen bonding. The article further discusses the pivotal processes of replication, transcription, and translation, highlighting recent advances in nucleic acid research. Finally, it examines the burgeoning field of nucleic acid-based therapies, including gene editing, RNA interference, and antisense oligonucleotides, underscoring their promise in treating genetic disorders and other diseases.

Keywords: Nucleic acids; DNA structure; RNA structure; Genetic information; Nucleotide metabolism; DNA replication; Transcription

Introduction

Nucleic acids, comprising DNA and RNA, are the cornerstone of biological information storage and transmission. Discovered in the 19th century, these molecules have since become central to our understanding of genetics and cellular function [1]. The biochemistry of nucleic acids involves studying their chemical properties, structural configurations, and roles in various biological processes. This article provides a comprehensive overview of nucleic acid biochemistry, focusing on their structure, function, and emerging therapeutic applications.

Structure of nucleic acids

Nucleic acids are polymers of nucleotides, each consisting of a phosphate group, a five-carbon sugar (deoxyribose in DNA and ribose in RNA), and a nitrogenous base [2]. The nitrogenous bases are divided into purines (adenine and guanine) and pyrimidines (cytosine, thymine in DNA, and uracil in RNA).

DNA structure

DNA is typically found in a double-helix structure, where two complementary strands wind around each other, stabilized by hydrogen bonds between paired bases (adenine-thymine and guanine-cytosine). This double-helix configuration was elucidated by Watson and Crick in 1953 and is essential for the molecule's stability and function [3].

RNA structure

RNA molecules are usually single-stranded but can fold into complex three-dimensional shapes due to intramolecular base pairing. These structures are critical for RNA's various functions, including catalysis and regulation.

Functional dynamics of nucleic acids

The primary functions of nucleic acids involve the storage, transmission, and expression of genetic information. These processes are mediated through replication, transcription, and translation [4].

DNA replication

DNA replication is a semi-conservative process where each strand of the double helix serves as a template for a new complementary strand. Key enzymes involved include DNA helicase, DNA polymerase, and DNA ligase. This process ensures the accurate transmission of genetic information during cell division.

Transcription

Transcription is the synthesis of RNA from a DNA template. RNA polymerase binds to specific regions of DNA, initiating the production of a complementary RNA strand. This process is tightly regulated to ensure appropriate gene expression [5,6].

Translation

Translation is the process by which mRNA is decoded to synthesize proteins. Ribosomes, tRNAs, and various enzymatic factors collaborate to translate the nucleotide sequence of mRNA into the amino acid sequence of a protein. This process is crucial for cellular function and response to environmental stimuli [7].

Recent advances in nucleic acid research

Recent technological advances have significantly enhanced our understanding of nucleic acid biochemistry. High-throughput sequencing, CRISPR-Cas9 gene editing, and advanced imaging techniques have opened new avenues for research and therapeutic applications [8].

High-throughput sequencing

Next-generation sequencing technologies have revolutionized genomics, enabling rapid and cost-effective sequencing of entire genomes. This has facilitated large-scale studies of genetic variation, disease associations, and evolutionary biology.

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Received: 01-May-2024, Manuscript No: bcp-24-141290, **Editor assigned:** 03-May-2024, Pre QC No: bcp-24-141290 (PQ), **Reviewed:** 18-May-2024, QC No: bcp-24-141290, **Revised:** 22-May-2024, Manuscript No: bcp-24-141290 (R) **Published:** 31-May-2024, DOI: 10.4172/2168-9652.1000469

Citation: Jian WL (2024) Insights into Nucleic Acid Biochemistry: Structure, Function, and Therapeutic Applications. Biochem Physiol 13: 469.

CRISPR-Cas9 gene editing

CRISPR-Cas9 has emerged as a powerful tool for precise genetic modifications. This technology allows researchers to target specific DNA sequences for editing, offering potential treatments for genetic disorders and advancing our understanding of gene function [9].

Advanced imaging techniques

Cryo-electron microscopy and other imaging methods have provided unprecedented views of nucleic acid structures and their interactions with proteins. These insights are crucial for understanding the molecular mechanisms underlying genetic processes.

Therapeutic applications of nucleic acids

Nucleic acid-based therapies are a promising area of medical research, offering new strategies for treating genetic disorders, cancers, and infectious diseases.

Gene therapy

Gene therapy involves the delivery of functional genes to replace or repair defective ones. Viral vectors, such as adeno-associated viruses (AAV), are commonly used to introduce therapeutic genes into target cells [10]. This approach has shown success in treating conditions like spinal muscular atrophy and inherited retinal diseases.

RNA interference (RNAi)

RNAi is a natural cellular process that silences gene expression by degrading mRNA molecules. Synthetic small interfering RNAs (siRNAs) can be designed to target specific mRNAs, reducing the expression of disease-causing genes. RNAi-based therapies are being developed for conditions like hypercholesterolemia and viral infections.

Antisense oligonucleotides (ASOs)

ASOs are short, synthetic DNA or RNA molecules that bind to complementary mRNA sequences, modulating gene expression. ASOs have been approved for treating diseases such as Duchenne muscular dystrophy and spinal muscular atrophy, demonstrating their therapeutic potential.

Conclusion

Nucleic acid biochemistry is a rapidly evolving field with profound implications for biology and medicine. Understanding the structure and function of nucleic acids has paved the way for innovative therapeutic strategies, offering hope for treating a wide range of diseases. As research progresses, the potential for nucleic acid-based interventions continues to expand, promising to transform healthcare in the coming years.

References

1. Chen Q, Ames BN (1994) Senescence-like growth arrest induced by hydrogen peroxide in human diploid fibroblast F65 cells. Proc Natl Acad Sci 91: 4130-4.
2. Chen H, Li Y, Tollefsbol TO (2013) Cell senescence culturing methods. Methods Mol Biol 1048: 1-10.
3. Kumazaki T (1991) Fibronectin expression increases during in vitro cellular senescence: correlation with increased cell area. Exp Cell Res 195: 13-9.
4. Chen QM (2000) Replicative senescence and oxidant-induced premature senescence. Beyond the control of cell cycle checkpoints. Ann N Y Acad Sci 908: 111-25.
5. Kuo LJ, Yang LX (2008) Gamma-H2AX - a novel biomarker for DNA double-strand breaks. In Vivo 22: 305-309.
6. Kyrylkova K (2012) Detection of apoptosis by TUNEL assay. Methods Mol Biol 887: 41-47.
7. Wurstle ML, Laussmann MA, Rehm M (2012) The central role of initiator caspase-9 in apoptosis signal transduction and the regulation of its activation and activity on the apoptosome. Exp Cell Res 318: 1213-1220.
8. Scholzen T, Gerdes J (2000) The Ki-67 protein: from the known and the unknown. J Cell Physiol 182: 311-322.
9. Bruey JM (2010) Circulating Ki-67 index in plasma as a biomarker and prognostic indicator in chronic lymphocytic leukemia. Leuk Res 34: 1320-1324.
10. Marthandan S (2015) Effects of ebselen and N-acetyl cysteine on replicative aging of primary human fibroblast strains. Immun Ageing 12: 8.