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Recent Advancements in Understanding Single RNA and its Relationship with DNA

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DESCRIPTION

In the field of molecular biology, the exploration of genetic information has been a cornerstone of scientific discovery for decades. DNA, or deoxyribonucleic acid, has long been recognized as the blueprint of life, holding the instructions necessary for the development, growth, and functioning of all living organisms. However, in recent years, a parallel focus has emerged on its counterpart, RNA (ribonucleic acid), and the intricate relationship it shares with DNA. This renewed interest has led to remarkable advancements in our understanding of single RNA and its complex interactions with DNA. Recent breakthroughs have highlighted the significance of single RNA molecules in modulating gene expression. Single-cell RNA sequencing technologies now enable scientists to analyse the RNA content of individual cells, providing insights into cellular heterogeneity and uncovering rare cell types that might be missed in bulk sequencing. This technology has revealed the dynamic nature of gene expression within different cell populations, shedding light on how various environmental factors and diseases can influence RNA activity. The concept of genetic information being fixed in the DNA sequence has been challenged by the discovery of RNA editing. RNA molecules can undergo modifications after transcription, altering their sequence and ultimately impacting protein synthesis. Adenosine-to-inosine (A-to-I) RNA editing is a well-studied example where adenosine bases in RNA are enzymatically converted to inosine. Since inosine is recognized as guanosine by the translational machinery, this process can lead to changes in protein coding sequences. Advancements in RNA editing techniques, such as CRISPR-Cas13, have enabled precise modifications of RNA sequences, offering unprecedented possibilities for gene therapy and disease treatment. This breakthrough technology has the potential to correct genetic mutations at the RNA level, preventing the expression of harmful proteins. Additionally, the development of small interfering RNAs (siRNAs) and antisense oligonucleotides (ASOs) has revolutionized the treatment of genetic disorders by allowing targeted gene silencing. These molecules can selectively inhibit the expression of disease-causing genes, offering new avenues for tackling conditions like Huntington's disease and amyotrophic lateral sclerosis (ALS). Furthermore, mRNA vaccines have gained global attention for their role in combating infectious diseases, as demonstrated by the rapid development and deployment of mRNA-based COVID-19 vaccines. This marks a significant milestone in personalized medicine and pandemic preparedness. Epitranscriptomics, the study of RNA modifications, has gained significant attention as researchers unravel the functional roles of various chemical modifications in RNA molecules. Modifications like methylation and pseudouridylation have been linked to crucial cellular processes including RNA stability, localization, and interaction with other molecules. Understanding these modifications has implications for disease research, as dysregulation of epitranscriptomic marks has been associated with conditions like cancer, neurodegenerative disorders, and viral infections. Beyond its intermediary role in protein synthesis, RNA has been found to engage in direct interactions with DNA molecules. Long non-coding RNAs (lncRNAs) have been discovered to bind to specific DNA sequences, influencing chromatin structure and gene expression. These interactions can either enhance or suppress gene transcription, adding another layer of complexity to our understanding of genetic regulation. Moreover, RNA molecules can also serve as guides for targeting DNA-modifying enzymes.

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CONFLICT OF INTEREST

The author states there is no conflict of interest.

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