Hidden superhero within us : Unveiling the Intriguing World of Long Non-Coding RNAs and Their Multifaceted Applications

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I. Abstract:

The class of endogenous, non-protein coding RNAs known as long non-coding RNAs (lncRNAs) is strongly associated with a variety of cellular functions and pathological processes. Long noncoding RNAs (lncRNAs), which were previously believed to be merely transcriptional junk and to have a passive or secondary function, are now known to play crucial roles in a variety of physiological as well as pathological processes, including cancer metastasis and drug resistance. They play a critical role in the pathogenesis of a variety of neurodegenerative, neurodevelopmental, and mental health disorders, including Alzheimer's disease .The identification and characterisation of lnRNAs that are deregulated or altered in brain function is essential to comprehending the complex transcriptional processes involved in brain functions. In the fight against cancer, long non-coded RNA has shown promise as a therapeutic target for the treatment of cancer, cardiovascular disease, and neurological disorders.

In this chapter, we will focus on how lncRNAs play a role in cancer and neurological disorders and neural development. We will also emphasize the enormous potential of lncRNAs as therapeutic agents and diagnostic biomarkers. We may anticipate the emergence of novel and creative uses in a variety of biological fields as we learn more about long non-coding RNA.

II . Introduction:

LncRNAs are a group of RNA molecules with more than 200 nucleotides that do not contain any protein-encoding sequences. LncRNAs were initially believed to be by-products of RNA polymerase II transcription and to have no biological purpose; however, as high-throughput sequencing technology has developed, a growing number of lncRNAs have been annotated, and their roles in tumorigenesis and tumor progression have gradually become clearer [1].

It is not intellectually gratifying to define lncRNAs solely in terms of their size and lack of ability to encode proteins. The need for such a broad classification of what are most likely to be functionally heterogeneous molecules is explained by the ease with which these transcripts can now be sequenced and our current incomplete understanding of their functions. Given that our ability to detect protein-coding transcripts has increased considerably over the past few years, it makes sense to define non-coding transcripts as those that are incapable of encoding proteins [2].

LncRNAs are produced through DNA transcription and share structural similarities with mRNAs. The lncRNAs are classified into antisense, intronic, divergent, intergenic, promoter-associated, transcription start site-associated, and enhancer RNAs (eRNAs) depending on chromosomal position of lncRNAs [1].

Environmental influences, which include a variety of stress reactions in animals and medication resistance in cancer, can also have a significant impact on lncRNA expression. This characteristic is particularly noticeable in plants.

lncRNAs have received a lot of attention recently because mounting evidence suggests that they are essential components of a number of biological processes, including gene transcription, chromatin remodeling, protein transport, trafficking, cell differentiation, organ or tissue development, cellular transport, metabolic processes, and chromosome dynamics [3].

III. Applications:

a. lncRNAs response to stress:

Long non-coding RNAs (lncRNAs) are typically non-protein coding by definition. Small open reading frames (ORFs) that can be translated and encode polypeptides with a variety of functions have, nevertheless, been reported in some. Most lncRNAs are transcribed by RNA polymerase (RNAP) II and capped, and many are spliced and polyadenylated, which is consistent with an mRNA-like function.
While many lncRNAs remain nuclear and are frequently unstable, these RNAs must localize to the cytoplasm in order to be translated.

Numerous long non-coding (lnc) RNAs that control rRNA transcription and other facets of cellular function are produced in nucleoli, which have long been recognised as the sites of rRNA synthesis and processing.
We now demonstrate that PAPAS, one such well-studied "lncRNA," surprisingly encodes a 25 KDa protein that we have termed RIEP (Ribosomal IGS Encoded Protein). When under stress, RIEP, which is substantially conserved in primates but absent in other species, localizes to nucleoli and mitochondria and then relocalizes to nuclear areas, where it works to prevent stress-related DNA damage.

A protein that appears to have recently developed from human nucleoli's rDNA is involved in the physiological response to stress and serves as a bridge between the nucleolus and mitochondria, the cell's major energy consumer and cell's major energy producer [4].

b. lncRNAs in Neural development:

The complicated process of development is influenced by environmental, genetic, and epigenetic cues. Long non-coding RNAs (lncRNAs) have recently come to light as important controllers of gene expression in a variety of organs, including the brain. There are a number of neurodegenerative, neurodevelopmental, and psychiatric illnesses that have been associated with altered lncRNA expression. Understanding the intricate transcriptional processes involved in brain function requires the discovery and characterization of lncRNAs that are dysregulated or altered in neurodevelopmental and mental health disorders.

The expression of LncRNAs changes dynamically as cells differentiate and mature. They have the ability to control stem cell reprogramming, genomic imprinting, and the cell cycle. More and more lncRNAs are particularly expressed during neural stem cell and progenitor differentiation as well as brain development. Examples include Sox2OT (Sox2 overlapping transcript), which overlaps the Sox2 gene encoding for a transcription factor crucial for neural stem cell self-renewal, and MALAT1 (metastasis-associated lung adenocarcinoma transcript 1), which controls synaptogenesis. The aberrant expression of lncRNAs impacts neurodevelopment and is a critical factor in the pathogenesis of a number of linked neuropathologies, including Down syndrome, Rett syndrome, Fragile X syndrome, and autism spectrum disorders [5].

c. lncRNAs role in neurological disorders:

The identification and characterisation of long noncoding RNAs (lncRNAs) that are deregulated or altered in neurodevelopmental and mental health problems is essential to comprehending the complex transcriptional processes involved in brain function.Importantly, lncRNAs can be used as a fresh target for the treatment of neurological diseases.

Progressive neuron malfunction or degeneration, which affects the functionality of the nervous system, characterize neurodegenerative illnesses. The subsequent clinical symptoms, both motor and cognitive, are distinctive to the particular illness and vary.

We chose prominent instances of lncRNA function in disorders like Alzheimer's disease (AD). One of the most common dementia-causing neurodegenerative disorders and conditions associated with aging is Alzheimer's disease. This condition is characterized by the gradual degeneration of cortical neurons, which causes atrophy of the brain tissue and clinical signs like dementia and cognitive impairment. Amyloid-beta buildup in external senile plaques and hyperphosphorylated tau protein in intracellular neurofibrillary tangles are the two primary symptoms of AD. However, a number of additional variables, including oxidative stress and neuroinflammation, can result in neurodegeneration.[5]

d. lncRNAs in agriculture:

Long non-coding RNAs (lncRNAs) are a family of RNA molecules that regulate the expression of genes rather than encoding for proteins. It has been demonstrated that lncRNAs have a role in a number of agriculturally significant features in plants, including yield, drought tolerance, and disease resistance.

LncRNAs can interact with proteins, RNA, and DNA to control how genes are expressed. They can serve as sponges to soak up and mute transcripts, or they can serve as scaffolding to join transcription factors and other regulatory proteins.

Examples of lncRNAs having crucial roles in agriculture include:

- LDMAR, which has been demonstrated to boost the grain yield of rice by 20%.
- IPS1, which has been demonstrated to boost tomato's ability to fight the bacterial disease Pseudomonas syringae.
- Zm401, which has been demonstrated to improve maize's resistance to drought stress.

Although research on lncRNAs in agriculture is still in its infancy, these molecules have the potential to significantly increase crop yields and stress resistance. We may anticipate the creation of novel breeding techniques that take use of the ability of these regulatory RNAs to increase agricultural output as our knowledge of lncRNAs continues to rise [6].

e. lncRNAs as biotherapeutics:

Long noncoding RNAs (lncRNAs) are a subclass of noncoding RNAs that are longer than 200 nucleotides. It has been demonstrated that these RNAs have significant biological functions in the control of gene expression, chromatin remodeling, and epigenetic modification. LncRNAs have become interesting therapeutic targets in recent years for the treatment of a number of illnesses, including cancer, cardiovascular disease, and neurological disorders.

ASO-ODN, which targets the lncRNA MALAT1 and has been demonstrated to stop lung cancer cells from growing and metastasizing both in vitro and in vivo, is one illustration of a lncRNA-based therapy. [7]

The use of siRNAs to target lncRNAs implicated in the development of cancer is one example of lncRNA-based therapies. In preclinical models of breast cancer, it has been demonstrated that siRNAs directed against the lncRNA HOTAIR can prevent tumor development and metastasis. Antisense oligonucleotides (ASOs) are another example, which are used to target lncRNAs linked to cardiovascular disorders.[8]

f. lncRNAs in Cancer treatment:

In the fight against cancer, long non-coding RNAs (lncRNAs) have shown promise as therapeutic targets. LncRNAs are a family of RNA molecules that do not encode proteins yet are essential for many biological functions, including the initiation and development of cancer. Their dysregulation has been linked to the development, spread, and resistance to treatment of tumors. New and powerful cancer treatments might be created by focusing on certain lncRNAs.[9]

One example of a lncRNA with therapeutic potential is Colon cancer-associated transcript 1-Long isoform (CCAT1-L). CCAT1-L affects long-range chromatin interactions at the MYC gene locus and is selectively expressed in colorectal cancer, where it promotes tumor development. Apoptosis is induced and colorectal cancer cell growth is inhibited when CCAT1-L is targeted, indicating the possibility of CCAT1-L as a therapeutic target.[10]

IV. Conclusion

Long non-coding RNAs (lncRNAs) have become important actors in biotherapeutics, cancer therapy, and agriculture. Numerous studies have been shown on how they affect chromatin remodeling, gene expression, and epigenetic changes. LncRNAs in agriculture hold potential for improving crop yields, stress tolerance, and disease resistance, opening the door to innovative breeding strategies and sustainable farming.

LncRNAs represent a novel therapeutic target in biotherapeutics for the treatment of a wide range of illnesses, including cancer, cardiovascular disease, and neurological disorders. In preclinical trials, targeting certain lncRNAs had positive results, paving the path for novel treatments for difficult-to-treat conditions.

Additionally, LncRNAs are important for brain growth and the root cause of neurological diseases. Potential therapeutic targets are lncRNAs, which have been associated with neurodevelopmental and mental health issues.

Despite advances, additional study is still required to completely comprehend the functional variety and therapeutic uses of lncRNAs. LncRNAs are set to influence biomedicine, agriculture, and our understanding of intricate biological processes as our awareness of them grows.

In conclusion, the study of lncRNAs is a fascinating and quickly developing topic with revolutionary promise in the biological sciences and medicine. Exploiting lncRNAs' potential might help solve urgent problems in healthcare and agriculture, which would be advantageous to society as a whole. A healthier, more sustainable future is just around the corner as we continue to unlock the secrets of lncRNAs.

V. Future perspectives

As our understanding of lncRNA biology continues to grow, we can expect to see the development of new lncRNA-based therapies for a wider range of diseases. LncRNAs have the potential to be employed in precision medicine, a personalized method of treating patients that takes into account each person's unique genetic profile. LncRNAs might be used, for instance, to identify people who are more likely to react to specific therapies or who are at risk for specific illnesses. LncRNAs may be utilized in gene editing processes like CRISPR-Cas9 to mute or change genes. The therapy of hereditary illnesses may benefit from this in the future. Cell therapy is a form of treatment in which cells are employed to deliver therapeutic drugs or to repair damaged tissue. LncRNAs may be used in this setting.

VI. Reference

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