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ISSN: 2153-0602
Journal of
Data Mining in
Genomics & Proteomics

Perspective

Peptide Repeat Proteins: Plant Adaptation in the Face of Environmental Challenges

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DESCRIPTION

Pentatrico-Peptide Repeat (PPR) proteins are a large and diverse family of RNA-binding proteins that are widely distributed in eukaryotes and some prokaryotes. PPR proteins are characterized by the presence of tandem repeats of a 35-amino acid motif that fold into a helix-turn-helix structure and bind to specific RNA sequences in a modular fashion. PPR proteins play important roles in various aspects of RNA metabolism, such as processing, splicing, editing, stability, and translation, mainly in organelles but also in the nucleus. In plants, PPR proteins are involved in the regulation of gene expression and function of chloroplasts and mitochondria, which are essential for photosynthesis, respiration, and stress responses. PPR proteins are also implicated in plant development, reproduction, and adaptation to environmental changes.

PPR proteins can be classified into different subclasses based on their domain architecture and function. The most common subclasses are P (containing only PPR motifs), PLS (containing additional E/E+ or S motifs at the C-terminus), E (containing an E domain at the C-terminus), and DYW (containing a DYW domain at the C-terminus). The PLS subclass is further divided into PLS-E, PLS-S, and PLS-DYW subtypes. The E and DYW domains are related to cytidine deaminase enzymes and are involved in RNA editing, which is the conversion of specific cytidines to uridines in organelle transcripts. The S motif is related to Small MutS-related (SMR) domains and may be involved in RNA cleavage or stabilization. Some PPR proteins also contain additional domains at their N- or C-termini that may mediate protein-protein interactions or enzymatic activities. For example, some PPR proteins contain tRNA Guanine-N7 Methyltransferase (TGM) domains that catalyze the methylation of guanine residues in tRNAs.

The molecular mechanisms of PPR-RNA recognition and regulation have been elucidated by structural and functional studies. PPR proteins bind to single-stranded RNA targets in a sequence-specific manner by forming a right-handed super helix around the RNA backbone. Each PPR motif recognizes one or two nucleotides through hydrogen bonds between amino acid side chains and RNA bases. The specificity of PPR-RNA interaction is determined by the number, order, and identity of the PPR motifs in each protein. The binding affinity and stability of PPR-RNA complexes depend on the length and composition of the RNA target, as well as the presence of additional domains or cofactors. PPR proteins can regulate RNA metabolism by different mechanisms, such as recruiting or blocking other factors, altering RNA structure or conformation, or catalyzing chemical modifications.

PPR proteins ating the expression and function of organelle genes. For example, PPR proteins are essential for the biogenesis and maintenance of chloroplasts and mitochondria by facilitating the processing, splicing, editing, stability, and translation of their transcripts. PPR proteins also regulate the expression of nuclear genes that encode organelle-targeted proteins by influencing their transcription or splicing. Moreover, PPR proteins are involved in plant development and reproduction by controlling the expression of genes related to floral organ identity, gametophyte development, pollen tube guidance, fertilization, embryogenesis, and seed development. Furthermore, PPR proteins are implicated in plant adaptation to environmental changes by modulating the expression of genes involved in photosynthesis, respiration, stress responses, circadian rhythms, and hormone signaling.

In conclusion, PPR proteins are versatile regulators of plant gene expression that act at different levels of RNA metabolism. They are essential for the proper function and coordination of organelles and nuclei in plant cells. They also play important roles in plant development, reproduction, and adaptation to environmental changes. The diversity and specificity of PPR proteins make them attractive tools for manipulating gene expression in plants for basic research and crop improvement. However, there are still many challenges and opportunities for further understanding the structure-function relationships, evolutionary origins, regulatory networks, and biotechnological applications of PPR proteins in plants.

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Received: 19-Apr-2023, Manuscript No. JDMGP-23-21527; **Editor assigned:** 21-Apr-2023, JDMGP-23-21527 (PQ); **Reviewed:** 05-May-2023, QC No. JDMGP-23-21527; **Revised:** 15-May-2023, Manuscript No. JDMGP-23-21527 (R); **Published:** 22-May-2023, DOI: 10.4172/2153-0602.23.14.295

Citation: Zhu Y (2023) Peptide Repeat Proteins: Plant Adaptation in the Face of Environmental Challenges. J Data Mining Genomics Proteomics. 14:295