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Short Communication

An Overview on Undecaprenol Biosynthesis in Plants and Animals Cells

Waser Kaya*

Department of Endocrinology and Metabolism, Zhongshan Hospital, Fudan University, Shanghai, China

DESCRIPTION

Undecaprenol, also known as bactoprenol, is a lipid carrier molecule that plays a crucial role in the biosynthesis of cell wall components in bacteria. The primary function of undecaprenol is to transport peptidoglycan precursors across the bacterial cell membrane during cell wall synthesis. Peptidoglycan is a major component of the bacterial cell wall and provides structural support and protection to the cell. The process of peptidoglycan biosynthesis involves the synthesis of the peptidoglycan subunit in the cytoplasm, which includes the assembly of N-Acetylglucosamine (NAG) and N-Acetylmuramic acid (NAM) along with a pentapeptide chain. Undecaprenol then plays a crucial role in carrying this peptidoglycan subunit across the bacterial membrane to the outer surface of the cell [1].

Biochemistry of undecaprenol

Undecaprenol is a polyisoprenoid alcohol with a specific structure that includes eleven isoprene units. The structure typically consists of a hydrophobic tail made up of multiple isoprene units and a hydrophilic head. Undecaprenol is synthesized through the mevalonate pathway in bacteria. The mevalonate pathway is responsible for the biosynthesis of isoprenoid compounds, including undecaprenol [2]. The primary function of undecaprenol is to serve as a carrier for peptidoglycan precursors during cell wall biosynthesis. These precursors include N-Acetylglucosamine (NAG) and N-Acetylmuramic acid (NAM), along with a pentapeptide chain. In the cytoplasm, the peptidoglycan subunit is synthesized, and it is then attached to undecaprenol, forming a lipid-linked intermediate. This lipid-linked intermediate is essential for transporting the peptidoglycan subunit across the bacterial membrane [3].

Undecaprenol, with the attached peptidoglycan subunit, undergoes a flip-flop mechanism across the bacterial membrane. This movement is crucial for transporting the peptidoglycan subunit from the cytoplasmic side to the outer surface of the cell membrane. Once on the outer surface of the membrane, the peptidoglycan subunit is incorporated into the growing peptidoglycan chain, contributing to the synthesis and expansion of the bacterial cell wall. Undecaprenol is a target for certain antibiotics, such as bacitracin. Bacitracin inhibits the dephosphorylation of undecaprenol, preventing its recycling and disrupting the transport of peptidoglycan precursors. This interference leads to the inhibition of peptidoglycan biosynthesis, ultimately causing cell wall defects and bacterial cell death [4].

Steps involved in peptidoglycan biosynthesis

- The peptidoglycan subunit is synthesized in the cytoplasm, involving the formation of NAG-NAM-pentapeptide.
- The peptidoglycan subunit is then attached to undecaprenol, forming a lipid-linked intermediate.
- Undecaprenol flips across the cell membrane, carrying the peptidoglycan subunit to the outer surface.
- The peptidoglycan subunit is incorporated into the growing peptidoglycan chain on the outer surface of the cell [5,6].

Undecaprenol in plant metabolism

Dolichol pathway: Undecaprenol is a type of dolichol, which is a long-chain polyisoprenoid alcohol. Plants use the dolichol pathway to synthesize glycoconjugates, including glycoproteins and glycolipids.In this pathway, undecaprenol serves as a lipid carrier for the transfer of glycan moieties during the synthesis of N-linked glycans. This process occurs in the Endoplasmic Reticulum (ER) of plant cells.

Glycoprotein synthesis: Undecaprenol is involved in the transfer of N-linked oligosaccharides to nascent polypeptides during the synthesis of glycoproteins in the ER. Glycoproteins are crucial for various cellular functions, including signaling, protein folding, and stability [7].

Cell wall biosynthesis: Undecaprenol is implicated in the biosynthesis of certain cell wall components in plants. While the primary structural components of plant cell walls differ from those in bacteria, undecaprenol is involved in the transfer of sugar moieties during the formation of glycosylated cell wall components. Glycosylation of cell wall proteins and other components is essential for cell wall structure and function [8,9].

Correspondence to: Waser Kaya, Department of Endocrinology and Metabolism, Zhongshan Hospital, Fudan University, Shanghai, China, E-mail: waserka@purdue.edu

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Membrane lipid synthesis: Undecaprenol contributes to the synthesis of membrane lipids in plants. It is involved in the transfer of sugar moieties during the glycosylation of lipids, influencing membrane properties and functions.

Biotic and abiotic stress responses: Recent studies suggest a potential role for undecaprenol in plant responses to stress conditions [10]. Changes in undecaprenol levels and glycoconjugate synthesis may contribute to plant adaptation to biotic and abiotic stresses.

CONCLUSION

Understanding the role of undecaprenol in plant metabolism is an evolving area of research. The dolichol pathway and its involvement in glycoconjugate synthesis are crucial for various cellular processes in plants. Antibiotics such as bacitracin target undecaprenol by inhibiting its dephosphorylation, leading to the disruption of peptidoglycan biosynthesis and ultimately bacterial cell death. The unique structure and function of undecaprenol make it an essential component in the biochemistry of bacterial cell wall synthesis.

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