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Opinion Article

An Overview of Plant Carbon Cycle *via* Krebs Cycle

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DESCRIPTION

The plant carbon cycle, an essential component of the global carbon cycle, includes the processes by which plants, predominantly through photosynthesis, absorb carbon dioxide (CO_2) from the atmosphere and convert it into organic compounds, primarily glucose. During photosynthesis, plants utilize sunlight, water, and CO_2 to produce glucose and release oxygen as a byproduct. This stored carbon is used for energy and growth, but it also plays a pivotal role in mitigating climate change by sequestering atmospheric carbon. The plant carbon cycle is essential for maintaining ecological balance, as it influences the carbon balance of ecosystems and contributes to regulating Earth's climate and overall environmental health. The Krebs cycle is a series of chemical reactions that plays a pivotal role in the cellular respiration of all aerobic organisms, including plants. It is a part of the larger metabolic pathway responsible for converting carbohydrates, fats, and proteins into Adenosine Triphosphate (ATP), the main source of energy for cells.

The general reaction for the Krebs cycle is

$$\text{Acetyl-CoA}+3NAD^{+}+FAD+GDP+P_i+2H_2O \rightarrow \text{CoA-SH} +3NADH$$

$$+FADH2+3H^{+}+GTP+2CO_2$$

The Krebs cycle takes in acetyl-CoA (derived from the breakdown of various nutrients) and, through a series of enzymatic reactions, generates ATP, high-energy electron carriers (NADH and FADH2), and carbon dioxide (CO_2).

Significance of the Krebs cycle in plants

Energy production: The foremost significance of the Krebs cycle in plants, as in all organisms, lies in its role as a powerhouse of energy production. As glucose and other organic molecules are broken down, acetyl-CoA is generated and enters the Krebs cycle. During this cycle, high-energy electrons are extracted, leading to the formation of NADH and FADH2. These molecules carry the energy derived from the Krebs cycle to the Electron Transport Chain (ETC) in the mitochondria, where ATP is synthesized. ATP is essential for various cellular processes, including active transport, growth, and reproduction.

Carbon skeleton production: While the primary role of the Krebs cycle is energy production, it also serves as a central hub for the generation of carbon skeletons. Carbon skeletons are the carbon-containing molecules that serve as building blocks for various organic compounds in plants. These include amino acids, nucleotides and certain secondary metabolites. The Krebs cycle releases CO_2 as a byproduct, which can be used in the formation of these essential compounds. By providing carbon skeletons, the Krebs cycle plays a vital role in plant growth and development.

Secondary metabolite production: The Krebs cycle is completely linked to the biosynthesis of secondary metabolites in plants. These compounds, which include alkaloids, phenolics, and terpenoids, serve diverse functions, such as defense against herbivores and pathogens, attraction of pollinators, and adaptation to environmental stress. The intermediates produced during the Krebs cycle can be diverted into various secondary metabolic pathways, leading to the production of these specialized compounds. For example, citric acid, an intermediate in the Krebs cycle, serves as a precursor for the biosynthesis of certain alkaloids.

pH regulation: The Krebs cycle can also influence the pH of plant cells and organelles. As it progresses, protons (H^+) are released into the mitochondrial matrix. This influx of protons contributes to the establishment of a proton gradient across the inner mitochondrial membrane, creating what is known as the proton motive force. This proton motive force plays a pivotal role in ATP synthesis and helps regulate the pH balance within the mitochondria, ensuring optimal enzyme activity and cellular functioning.

The interplay with other metabolic pathways

The Krebs cycle is not an isolated metabolic pathway; it interacts intricately with other pathways within plant cells. One such interaction is with the glycolysis pathway, which converts glucose into pyruvate. This ultimately leads to the production of acetyl-CoA, a key player in the Krebs cycle.

Glycolysis: In glycolysis, glucose is partially oxidized to produce pyruvate. This pyruvate can be further converted into acetyl-CoA, which feeds directly into the Krebs cycle. This connection allows

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allows plants to derive energy from a variety of carbohydrates, not just glucose.

Glucose storage: The Krebs cycle also connects with the process of glucose storage in the form of starch. Glucose molecules are polymerized into starch granules, which can later be broken down into glucose and then enter the glycolysis and Krebs cycle pathways to provide energy when needed.

Amino acid biosynthesis: Several amino acids, the building blocks of proteins, are directly or indirectly connected to the Krebs cycle. Intermediates in the Krebs cycle can be diverted into pathways that synthesize amino acids, ensuring a steady supply of these essential molecules for protein synthesis.

CONCLUSION

The Krebs cycle is a metabolic basis in the world of plants, with far-reaching implications for their growth, development, and adaptation to frequently changing environments. Its significance goes beyond energy production; it plays a central role in the biosynthesis of essential compounds, secondary metabolites, and the regulation of cellular processes. The Knowledge of the Krebs cycle provides practical implications for agriculture, horticulture, environmental conservation and improves our knowledge for the botanical world. The Krebs cycle, a symbol of metabolic elegance, remains a testament to the exceptional adaptations and strategies that enable the plant growth in diverse ecosystems across the globe.