

Unveiling the Vital Role of FADH₂ in Metabolism

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DESCRIPTION

In the intricate world of plant biology, the process of energy conversion is important for biochemical reactions. The Electron Transport Chain (ETC), a vital process responsible for generating Adenosine Triphosphate (ATP), the energy currency of cells. While Nicotinamide Adenine Dinucleotide (NADH) had a lot of consideration, Flavin Adenine Dinucleotide (FADH₂) also plays a significant role in this process. Electron transport chain is a phenomenal process occurs within the inner mitochondrial membrane of plant cells (similar process as in animal cells) and is important for the production of ATP, the cells internal reserve of energy. The ETC is a series of protein complexes and electron carriers that shuttle high-energy electrons derived from the breakdown of glucose and other organic molecules through a sequence of redox reactions. These electrons gradually lose their energy as they move through the chain and, in doing so, pump protons (H⁺) across the inner mitochondrial membrane into the intermembrane space, creating a proton gradient. This gradient, also known as the proton motive force, which promotes the production of ATP.

The key components of the electron transport chain include NADH, FADH₂, a series of protein complexes (I, II, III, and IV), and two mobile electron carriers, ubiquinone (Coenzyme Q) and cytochrome C. While NADH is usually in the spotlight due to its role in complex I, FADH₂ plays a pivotal role in complex II and complements the overall functioning of the ETC.

Role of FAD

Flavin Adenine Dinucleotide (FAD) is a coenzyme that plays a central role in various metabolic processes, including the ETC. FAD is derived from riboflavin, also known as vitamin B₂, which is an essential nutrient for plants and animals alike. When FAD accepts two hydrogen atoms and two electrons, it becomes reduced and transforms into FADH₂. This FADH₂ is important in complex II of the electron transport chain. Complex II, also known as Succinate Dehydrogenase (SDH), is the entry point for FADH₂ into the electron transport chain. This complex holds a unique position in the ETC as it connects

the TCA (Tricarboxylic Acid) cycle, also known as the citric acid cycle or Krebs cycle, with the ETC.

Mechanism of metabolism

TCA cycle connection: In the TCA cycle, organic molecules, such as succinate, undergo a series of reactions that ultimately produce FADH₂. Succinate, in particular, is oxidized by succinate dehydrogenase, leading to the formation of FADH₂.

FADH₂ formation: This FADH₂ produced in the TCA cycle is directly transferred to complex II. Here, succinate dehydrogenase catalyzes the conversion of succinate to fumarate while simultaneously transferring electrons from FADH₂ to FAD, converting it back into its oxidized form, FAD. The electrons derived from FADH₂ are then transferred to the electron transport chain.

Electron transfer: Once the electrons are transferred to the ETC, they enter the chain at the level of ubiquinone (Coenzyme Q), specifically in complex III. From here, they proceed through the chain, ultimately driving the pumping of protons and ATP synthesis.

Role of FADH₂

Despite being partially replaced by NADH, FADH₂ plays an vital role in the overall efficiency of the electron transport chain and ATP production. Here are a few reasons for FADH₂ importance in metabolism:

ATP production: FADH₂ contributes to ATP production in the electron transport chain. While NADH transfers electrons early in the chain at complex I, FADH₂ enters later at complex II. This means that electrons derived from FADH₂ skip the initial proton-pumping step, contributing to a slightly lower proton motive force. As a result, the electrons from FADH₂ generate fewer ATP molecules than those from NADH. However, they still play a significant role in overall energy production.

Redox balance: The presence of FADH₂ in complex II helps maintain redox balance in the cell. The TCA cycle, in which FADH₂ is generated, is essential for the breakdown of various organic molecules, not just glucose. By participating in this cycle,

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FADH₂ ensures that the ETC can receive electrons from a variety of metabolic pathways, helping to maintain the cell's energy balance.

Metabolic flexibility: Plants, like all organisms, must adapt to varying environmental conditions and energy demands. The presence of FADH₂ in complex II provides metabolic flexibility. Depending on the metabolic pathways being utilized, FADH₂ can be generated and directed into the electron transport chain, contributing to ATP production when needed.

CONCLUSION

With respect to plant biology, the Electron Transport Chain unfolds as a mesmerizing performance, with FADH₂ playing a

crucial but often ignored role. This is derived from the TCA cycle, enters the chain at complex II, contributing to ATP production and helping maintain redox balance in the cell. While NADH may take center stage in discussions about the ETC, it is important to recognize that FADH₂ is a vital player, allowing plants to adapt to changing energy demands and maintain metabolic flexibility. Our understanding of FADH₂'s function in sustaining life on Earth grows as scientists continue to eliminate the complex processes that take place within plant cells, which serves as a constant reminder of the amazing complexity and capability of the natural world.