The mitochondrion

Introduction:

Within the eukaryotic cell, exists an intracellular, double membraned organelle, that acts as the powerhouse of the cell, called Mitochondria. (Protasoni, 2012). An organelle which according to theories, evolved from a free living bacteria to the powerhouse of eukaryotic cells (that does not depend on photosynthesis) by the process of endosymbiosis. (Their role in generating Adenine Triphosphate (ATP) helps provide the body with energy needed for many essential processes. With a lifespan of 5 to 10 days, the organelle discovered by Altmann and named by Carl Benda were proven to be vital for our survival. (Allen, A. 2012)

Endosymbiotic theory:

As proposed by Lynn Margulis in the 1960s, mitochondria's origin traces back to a symbiotic relationship that resulted from the interaction of free-living bacteria and the ancestral eukaryotic cell. As the cell engulfed the bacteria resembling proteobacteria, the relationship stabilised leading to merging of the bacteria otherwise the mitochondria into the host cell's structure. This hypothesis was supported by the discovery of the mitochondrial DNA and an independent mitochondrial translated system. (Deusch, O.; et al. 2008)

Structure:

The small, bean-shaped organelle known as the mitochondria possesses a very unique and distinctive structure that reflects its crucial role in metabolism. Similar to other organelles, mitochondria is not visible under the microscope unless stained. Bounded by a double membrane system, both the outer and inner membrane of the mitochondria display a role each in the mechanism of the organelle, as the outer membrane serves as a semi-permeable barrier (as well as containing more phospholipid and cholesterol), while the inner membrane is thrown up into a series of folds called the cristae. Between both the outer and inner membrane lies the intermembrane space, which is involved in mitochondrial protein translocation. It also contains its own unique genome known as the mitochondrial DNA which resides in the Matrix (a gel-like substance, containing hundreds of enzymes that lies in the inner membrane). (Kuhlbrandt, 2015)

Role in ATP:

As the powerhouse of the cell, mitochondria plays a crucial role in providing energy for the body. This help is provided by many ways, most famously the production of energy in the form ATP. This occurs by the process of oxidative phosphorylation which involves a series of key biological reactions. Firstly, inside the mitochondria is the electron transport system, a crucial process which comes from breaking down food that acts as a conveyer belt for electrons. As electrons move across the electron transport system, proton pumping and gradient occurs. The energy used in protein gradient is then used to synthesize ATP from ADP and inorganic phosphate. This is finally followed by chemiosmosis and ATP production.

Roles beyond ATP:

1. Metabolism

It is widely known that the primary function of mitochondria is the production of Adenosine Triphosphate through cellular reproduction, a process which involves a sequent of consecutive events involving Glycolysis, Krebs cycle and the electron transport chain. Other than that, the mitochondria is involved in a series of pivotal activities in the eukaryotic body, such metabolism. Beyond the metabolism involved in ATP production, the mitochondria contributes in various metabolic activities, such as fatty acids, amino acids and glucose metabolism. In the liver mitochondria, occurs ketogenesis, which is the metabolism of ketone bodies that takes place during periods of fasting or low carbohydrate intake. It also contributes to the synthesis of lipids and heme. The mitochondria also ensures the secured elimination of nitrogen wastes from the human body in a process called the Urea cycle.

2. Apoptosis Regulation

Beyond the mitochondrial role in ATP production is the mitochondrial regulation of apoptosis. Apoptosis which means the programmed cell death is a tightly controlled process pivotal for development, tissue homeostasis and the elimination spoiled cells. During this regulation, mitochondrial proteins known as cytochrome c are released into the cytoplasm, under stressful conditions where a complex relationship is formed between it and other proteins, leading to a cell death. However, with the help of mitochondria under physiological conditions, a balanced relationship between pro-apoptotic and anti-apoptotic factors are maintained. These processes of apoptosis involving mitochondrial as energy producers and guardians of cellular integrity aids in further influencing crucial processes that shape the fate of the eukaryotic cell.

3. Heat Production

As a by-product of oxidative metabolism and a major factor in thermoregulation, mitochondrion are considered as the main heat generating organelle in the body. This production of heat provides the body with warmth and maintains the body temperature in response to environmental hazards, and the mitoc

hondria contributes to this in a process called the non-shivering thermogenesis (a process which takes place in brown fat tissue, where mitochondria use the protein UCP1 to produce heat). This process takes place through the disassembling of proton transport and ATP synthesis. Despite this being mostly prominent in brown adipose tissue, the mitochondria still manages to contribute to thermoregulation across a variety cells.

Conclusion:

Concluding this text, mitochondria stand as vital cell components with a unique structure optimised for energy production. With their unique double-membraned structure, they are able to house and create an environment suitable for oxidative phosphorylation, converting nutrients from food into ATP energy. Their adaptability and various other roles makes them essential for maintaining cellular health. Dysfunctional mitochondria are related to a variety of diseases. In essence, mitochondria plays an indispensable role in cellular vitality and the broader landscape of life.

References:

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