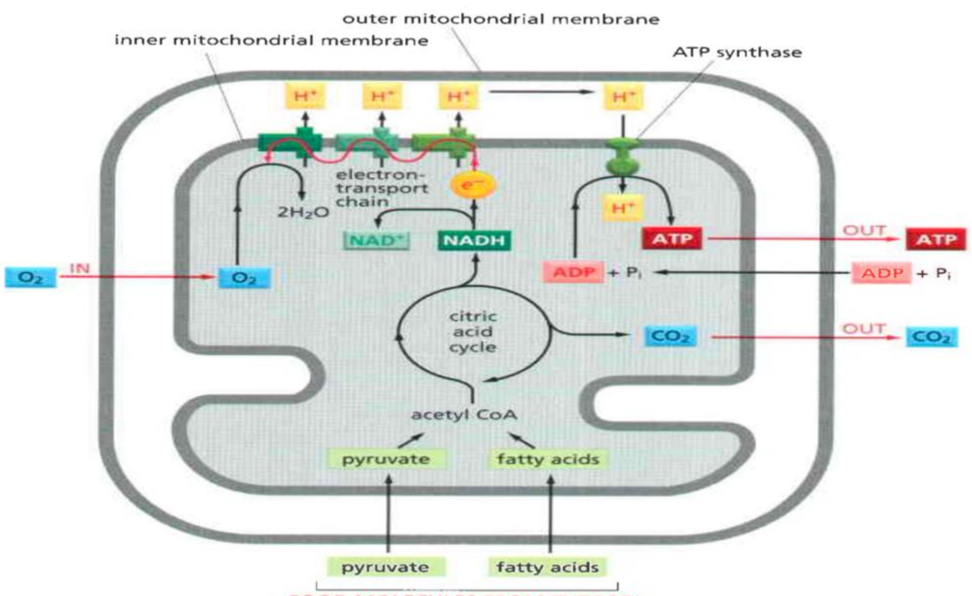
Reading Summary 2

Energy Conversion in Mitochondria

In all Eukaryotes energy in the form of ATP is produced in the mitochondrion. This process uses nutrients to produce ATP, a continuous process required to keep organisms alive. The process in the mitochondrion starts with fatty acid and pyruvate molecules entering the matrix from the cytoplasm. These are first broken down into Acetyl-coA, a molecule that is involved in many metabolic processes. Here it undergoes the citric acid cycle that converts NAD^+ to NADH(reduction by addition of electron) and generates carbon dioxide as a biproduct. This is a highly unstable configuration, which gives out an high energy electron when it returns to NAP^+. This electron goes through the electron transport chain, a set of three enzyme complexes that are responsible for maintaining a potential difference across the inner membrane by pumping protons out of the matrix. This process involve oxygen as one of the reactants and produces water as a side product. ADP+P enter the matrix. ATP synthase, a specialized enzyme on the inner membrane uses the excess protons available in the intramembrane space to append the additional phosphate to ADP, an extra proton is now present in the matrix.

Taking a step back from the intricate and complex process of ATP synthesis, it is easier to analyse the flow of energy. Energy derived from food in the form of nutrients enters the mitochondrion. These molecules are used to convert NAD^+ to NADH and back to NAD^+. The electron released drives the electron transport chain that pumps the H^+ ions out of the matrix. The gradient across the membrane acts like a battery that stores energy. When ADP is converted to ATP there is a transfer of energy once again, and a corresponding potential drop across the membrane. This is not the only way by which the proton gradient facilitates the ATP synthesis, in fact it also helps transport molecules in and out of the matrix. For example Pyruvate and phosphate are transported along with the hydrogen ions into the matrix, while ATP and ADP are transported in



A clearer understanding of the basic structure of the mitochondria helps understand the process better and puts the synthesis process in to spatial perspective. Mitochondrion consists of two semipermeable membranes, an inner and outer layer, which give rise to two distinct cavities. The outer layer of the mitochondria contains many specialized protein molecules that facilitate the movement of large amounts of water. The inner membrane on the other hand is a lipid bilayer that is highly selective, especially when it comes to ions, and smaller molecules. Due to this the matrix, the inner cavity is ripe with the various molecules in the right concentrations to produce ATP. These unique characteristics of the membranes are used by scientist to extract the contents of each cavity. Initially the mitochondria are introduced into a medium of low osmolarity, since the outer layer is permeable to water, the inter membrane space expands and causes the outer membrane to rupture. The contents of the outer layer can be centrifuged out easily. The inner membrane and the internal matrix are then transferred to a medium of high osmolarity, causing the outer membrane to shrink and reform. Since the density of the outer membrane and the matrix are considerably different, a density gradient centrifuge is used to separate the two. The inner membrane is "gently disrupted" and the contents centrifuged to separate all the individual components.

$$\Delta G = \Delta G^{\circ} + RT \ln \frac{[B][C]}{[A]}$$

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In the above formula, A,B and C are ATP, ADP and Phosphate.

From the above formula it is clear that [A] must be greater than [B][C] in order for the free energy to be negative, the condition at which ATP production is spontaneous. It is found that when the concentrations of the reactants and the products are equal, the free energy just $\Delta G = \Delta G^0 =$ -7.3 kcal/mol) affirming that ATP production is indeed spontaneous. At equilibrium it would be expected that this energy would be zero, this would only take place when the concentration of reactants is much higher than the product. In the cell however there is a vast difference between the concentration of ATP and ADP, favouring ATP which leads to the large negative free energy value that makes energy production in Eukaryotic cells highly efficient.