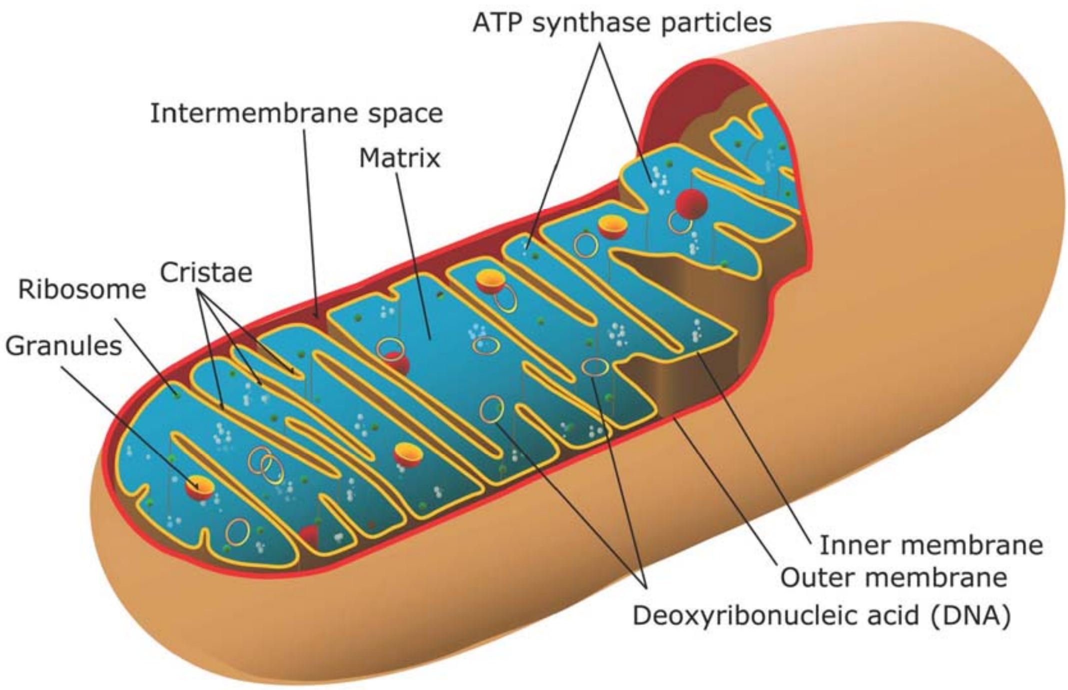
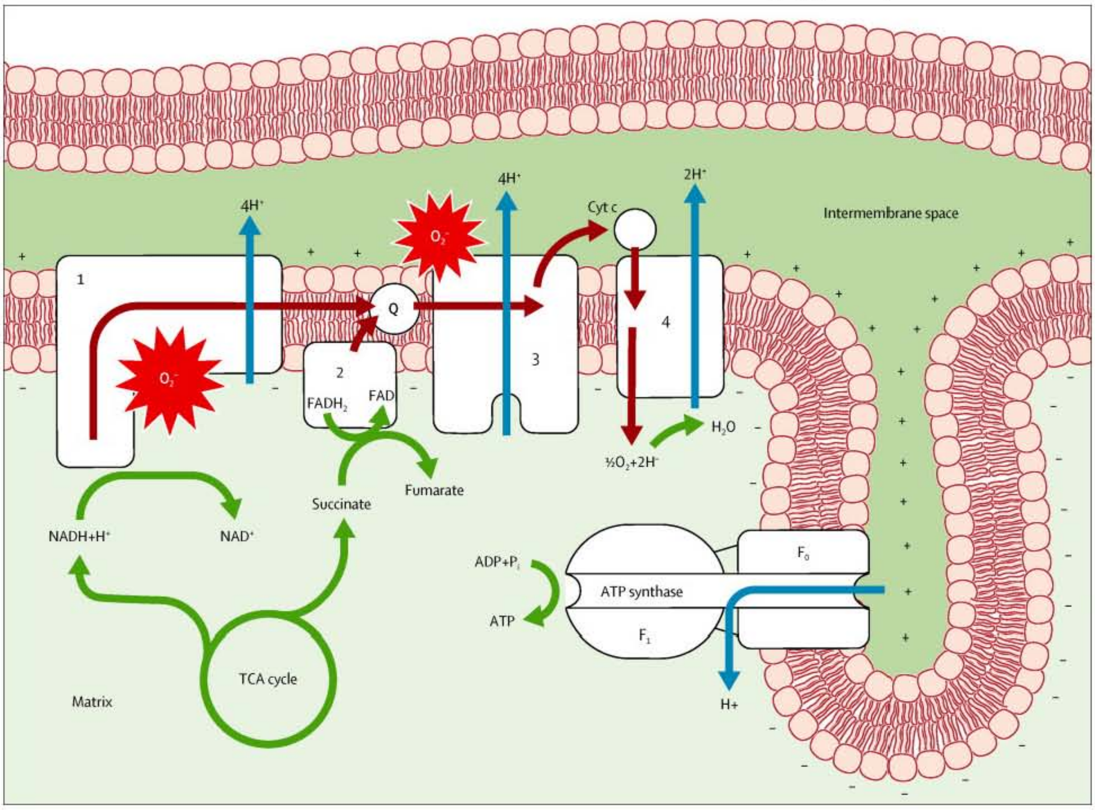
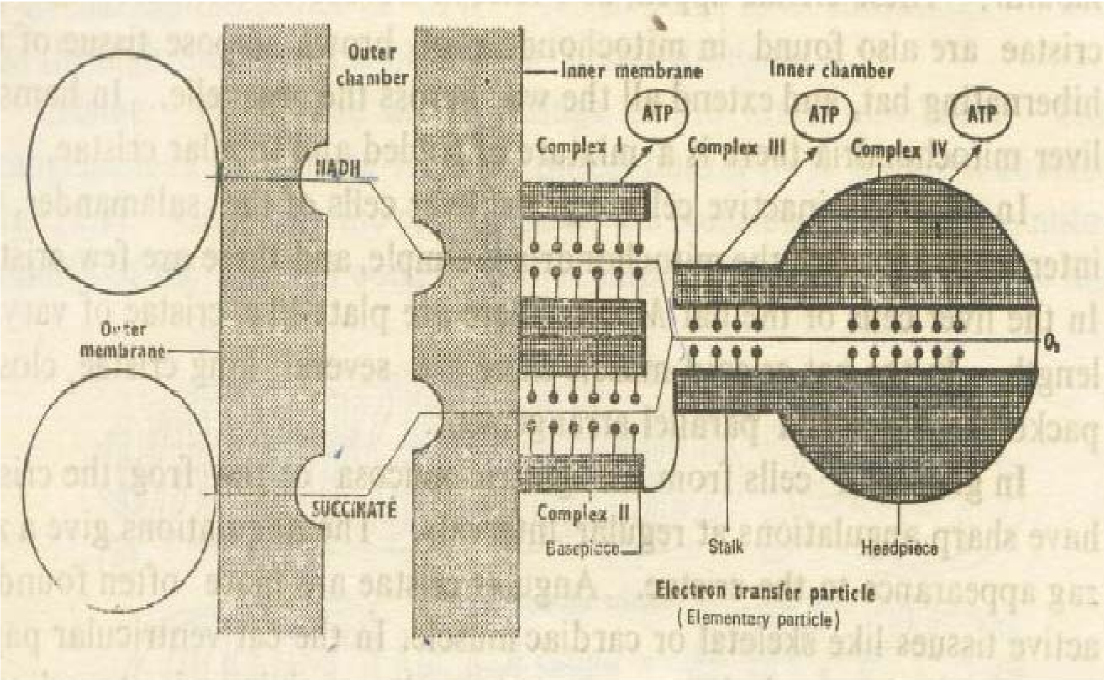
Structure of mitochondrion



Mitochondria have two membranes, inner and outer. The latter serves largely as an outer boundary and is not the locus of major mitochondrial functions, whereas the inner membrane contains many proteins with important functions, including those that allow molecules to enter into, or exit from, the mitochondrial matrix.



The internal aqueous phase of mitochondria is known as the matrix. Apart from the mtDNA, many proteins are located in the matrix. Prominent is the set of catalysts (enzymes) for a series of reactions known as the Krebs' cycle or tricarboxylic acid cycle (see also Aerobic Respiration). This cycle receives a chemical unit known as the acetyl group that is derived from the breakdown of sugars, fats, and proteins by cells. Precursors of the acetyl group are transported from the cell cytoplasm into the matrix via some of the proteins in the inner membrane. The reactions of the Krebs' cycle abstract electrons from the acetyl group and transfer them to two kinds of molecule that can subsequently pass them on to the electron transport chain that is described below. The two carbon atoms are converted into carbon dioxide, which is usually released from the cell.



The mitochondrial matrix also contains enzymes for catalysing other important cell reactions. For example, the mitochondrion is the location for synthesis of the pigment haem found, for instance, in the oxygen-carrying protein haemoglobin, while the mitochondria of liver cells in terrestrial animals catalyse the synthesis of urea, a molecule whose excretion from the body removes unwanted nitrogen. This example illustrates that whereas mitochondria from different cell types have many features in common, they also have different capabilities depending upon the cell type in which they reside. Thus plant mitochondria are involved in reactions not found in mammalian cells.

The protein machinery that couples respiration, the uptake of oxygen, to energy provision is located in the inner membrane. The process is known as oxidative phosphorylation.

Complex proteins, collectively known as the electron transfer (or transport) chain, in the inner membrane transfer to oxygen the electrons released from the acetyl group by the reactions of the Krebs' cycle. The oxygen is converted to water, which is thus, along with carbon dioxide, a product of respiration. The electron transfer process is energetically “downhill”, that is, overall it releases energy. In the mitochondria of some cells, for example, those of certain brown fat cells in mammals and rodents, this energy is given out as heat, but usually it is harnessed for the synthesis of adenosine triphosphate (ATP) from adenosine diphosphate (ADP) and phosphate. The ATP is synthesized on the matrix-facing side of the inner membrane and most of it is subsequently exported through the inner membrane to the cytoplasm where it is used in many cell processes, for example, driving contraction in muscle cells. The ADP that is thereby produced is imported back into mitochondria in exchange for the exported ATP.

The coupling of the transfer of electrons to oxygen to the synthesis of ATP is known as the process of oxidative phosphorylation.

Some of the protein units of the electron transport system have their genetic information carried by mtDNA. Mutations in mtDNA can result in defective electron transfer proteins and hence cause human diseases. There is also a view that mutations in mtDNA occur more frequently than in the nuclear DNA and are a major contributor to the ageing process.

Mitochondria are often called the powerhouses of the cell and as such can be thought of as keeping the cells alive. Recently, it has been surprisingly proposed that mitochondria play a central role in the process of programmed cell death, known as apoptosis. This means that under certain specialized conditions a process is triggered in cells that leads to regulated degradation of cell materials. The exact role(s) of mitochondria in this process are still under debate, but underscore the fact that although mitochondria are physically distinct entities in the eukaryotic cell, their essential functions are not independent, but rather are fully integrated into both the life and death of cells.