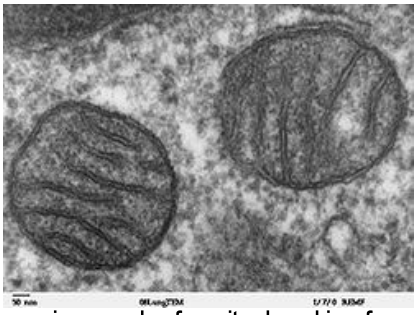
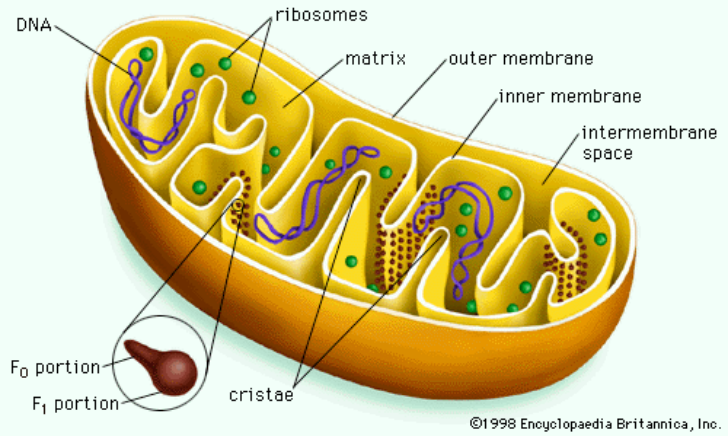
Mitochondria in Eukaryotic Cells

Mitochondria are the energy factories in eukaryotic cells. They are small organelles that provide the vast majority of energy for the cell in the form of ATP, generated by a process known as oxidative phosphorylation. The diameter of mitochondria ranges in size from 0.5 to 10 µm and their number varies per cell type from just one to several thousand. The mitochondrion has its own, independent genome that has many similarities to the bacterial genome, and in fact, mitochondria are sometimes referred to as "endosymbiotic prokaryotes" according to the hypothesis that mitochondria derived from endocytosed bacteria more than 1 billion years ago.



Electron micrograph of a mitochondrion from mammalian lung tissue showing its matrix and membranes. (Source: Wikipedia)

Mitochondria are made up of 5 compartments with different functions. 1) The outer membrane is permeable to proteins <5000 Daltons due to the presence of large protein channels called porins; 2) The intermembrane space is where the electron carrier cytochrome *c* is located. The concentration of sugars, ions and other small molecules is the same in this compartment as in the cytosol due to the presence of porins in the outer membrane; 3) The inner membrane is protein rich and contains the proteins involved in oxidative phosphorylation. 4) Cristae are structures that expand the surface area of the inner membrane, making its surface area larger than that of the outer membrane; 5) The mitochondrial matrix is contained by the inner membrane. It is the location of mitochondrial DNA, and proteins involved in the citric acid cycle, the oxidation of pyruvate, and the β-oxidation of fatty acids.



ATP is produced by the mitochondria during the process of oxidative phosphorylation. Complexes I, III, and IV of the electron transport chain generate a proton gradient over the mitochondrial inner membrane that ATPsynthase uses to synthesize ATP (see figure below). These protein complexes facilitate transport of electrons in the inner membrane via coenzyme Q, ultimately leading to the reduction of oxygen, and use the energy released during electron transport to pump protons from the mitochondrial matrix into the mitochondrial inter membrane space, thus generating the proton gradient. Electrons are derived from cellular reducing power in the forms of NADH, $FADH_2$, and metabolized substrate (in this optimized scenario, succinate), with NADH being the main electron donor. NADH is supplied via three interconnected pathways: glycolysis, citric acid cycle, and the ß-oxidation of fatty acids.