Cell organelles

Mitochondria (powerhouse of cell)

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Definition

Are membrane-bound organelles lying in the cytoplasm. They are spherical or filamentous (rod- shape) structures with the size about (0.5-1µm) wide with length up to 10µm.

Mitochondria are known as the powerhouses of the cell. They are organelles that act like a digestive system which takes in nutrients, breaks them down, and creates energy rich molecules for the cell. The biochemical processes of the cell are known as cellular respiration**.** Many of the reactions involved in cellular respiration happen in the mitochondria. Mitochondria are the working organelles that keep the cell full of energy.

The characteristics feature

- The mitochondria vary in number with cell activity.

- They found in few numbers in lymphocytes and epithelial cells, but large number in cells with high metabolic activity as kidney tubule cells and cardiac muscle cells.

●The location also varied within the cell, correlate with the functional requirements.

●They tend to accumulate in parts of the cytoplasm where metabolic activity is high such as the apical ends of ciliated cells, in the middle piece of spermatozoa or at the base of ion-transferring cells.

The structure of mitochondria

Under the electron microscope, the mitochondrion is surrounded by two unit membranes separated by an **intermembranous space**. These are outer and inner mitochondrial membranes composed of phospholipid bilayers and proteins. The two membranes have different properties, the **outer mitochondrial membrane** is fairly permeable, but the **inner mitochondrial membrane** is more selective.

The outer membrane contains large numbers of integral proteins called porins. These porins form channels that allow molecules to diffuse from one side of the membrane to the other. Larger proteins can enter the mitochondrion if binds to a large multi-subunit protein called **translocase** of the outer membrane, which then actively moves them across the membrane. The mitochondrial outer membrane can associate with the endoplasmic reticulum which involved in the transfer of lipids between them.

The inner membrane is rich in phospholipid (cardiolipin). Cardiolipin contains four fatty acids rather than two and may help to make the inner membrane impermeable. The inner membrane projects numerous folds into the interior of mitochondria to form **cristae,** which expand the surface area of the inner mitochondrial membrane, enhancing its ability to produce ATP.

These cristae vary from tubular to vesicular or transverse forms. Some liver mitochondria, for example, the surface area, including cristae, is about five times that of the outer membrane. Mitochondria of cells that have greater demand for ATP, such as muscle cells, contain more cristae than typical liver mitochondria.

The space between the inner and outer membranes is called **intermembrane space** which is continuous with **intracristal space** that penetrate the cristae. The other space is **intercristae** or **matrix space**, it is enclosed by inner membrane and its penetrated by the cristae. The presence of cristae of the inner membrane is increase the internal surface area of mitochondria. It contain enzymes and other components of oxidative phosphorylation and electron transport systems.

There are numerous globular structures connected to the inner membrane by cylindrical stalks, these particles called **elementary particles** or **respiratory stalks**. These particles are contain the enzyme complex that couples electron transport to oxidative phosphorylation, where synthesis ATP (adenosine triphosphate) from ADP (adenosine diphosphate) , inorganic phosphate and energy .

The matrix space contain rounded electron-dense granules called **intramitochondrial granules** which is rich in cations such Ca^{+2} and Mg^{+2}. The function of these granules is not completely understood. It may be important in regulating the activity of some mitochondrial enzymes, also is related to the ability of mitochondria to concentrate cations. The matrix contains a highly-concentrated mixture of enzymes The matrix contain enzymes for citric acid cycle (Krebs cycle) and fatty acid B- oxidation.

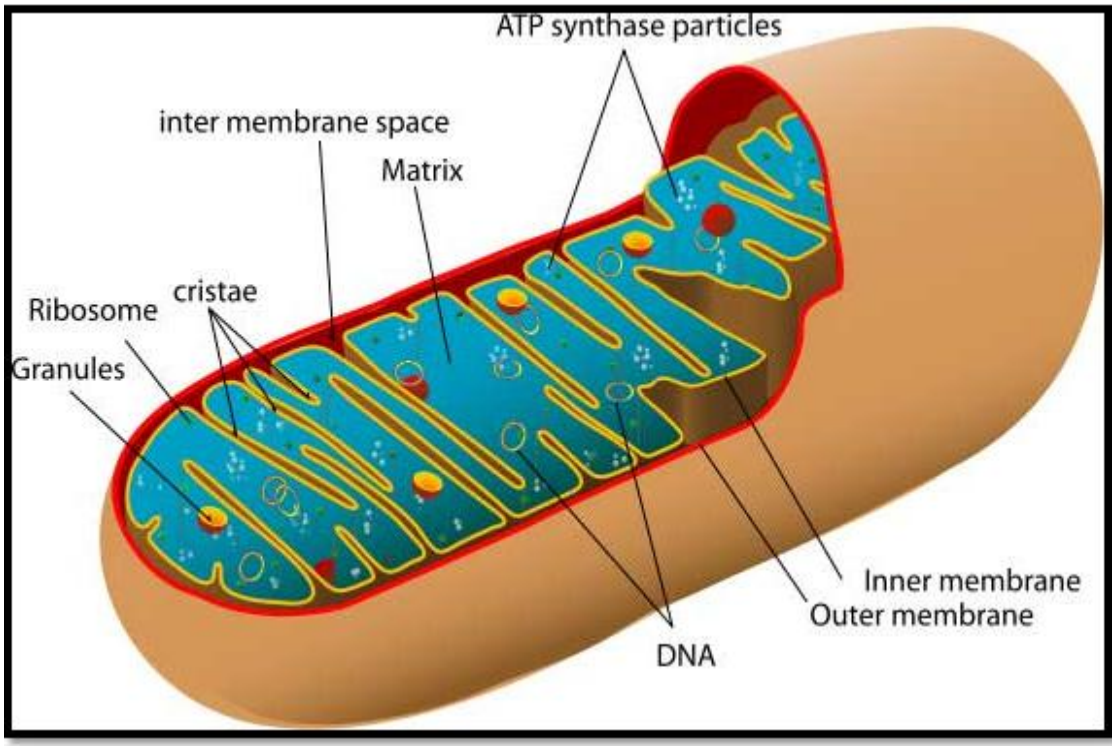
The matrix also contains high concentration of proteins, fine strands of DNA, RNA (mRNA, rRNA, tRNA) and ribosomes. The DNA has circular double - stranded structure and synthesized within the mitochondria and its duplication is independent on the nuclear DNA replication. Mitochondrial ribosomes are smaller than that of the cytosol .

The Functions of mitochondria

1- Those that perform the redox reactions of oxidative phosphorylation.
2- ATP synthase, which generates ATP in the matrix.
3- Specific transport proteins that regulate metabolite passage into and out of the matrix.
4- Protein import machinery.

Oxidative phosphorylation

The mitochondria are the major source of energy within the cells that have high efficient to transform the chemical energy of metabolites that present in cytoplasm into energy. Metabolites are degraded within mitochondria by the catalytic activity of the enzymes of the citric acid cycle, and the energy liberated in this process is partially captured through oxidative phosphorylation. The end result of these reactions is the production of CO_2, water, and heat, as well as the accumulation of energy in the high-energy compound ATP. About 50% of this energy stored as high- energy phosphate bonds in ATP molecules, and the remaining 50% is dissipated as heat used to maintain body temperature. Through the activity of enzyme ATPase, ATP promptly releases energy when required by the cell to perform any work (osmotic, mechanical or chemical).

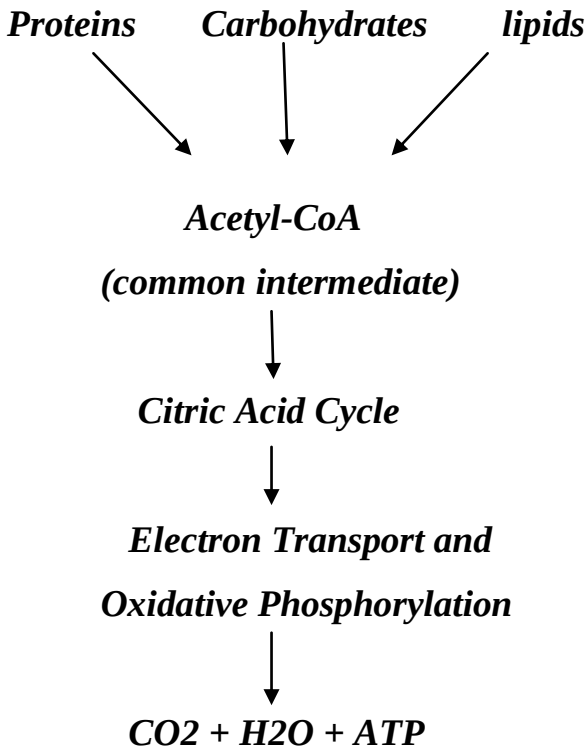


The initial degradation of proteins, carbohydrates, and fats is carried out in the cytoplasm matrix. The metabolic end product of these extramitochondrial metabolic pathways is acetyl-coenzymes A (CoA), which then enters mitochondria.

Within mitochondria, acetyl-coenzymes A combines with oxaloacetate to form citric acid. Within the citric acid cycle, several reactions of decarboxylation produce CO_2 , and specific reactions catalyzed by dehydrogenases result in the removal of four pairs of H^+ ions. The H^+ ions ultimately react with oxygen to form H_2O. Through the action of cytochromes, and cytochrome oxidase, the electron transport system, located in the inner mitochondrial membrane, release energy that is captured at three points of this system through the formation of ATP from ADP and inorganic phosphate.

Under aerobic conditions, the combined activity of extramitochondrial glycolsis and the citric acid cycle as well as the electron transport system gives rise to 36 molecules of ATP per molecule of glucose. This is 18 times the energy obtainable under anaerobic circumstances, when only the glycolytic pathway can be used.

The principal means by which the cell obtains energy for its metabolic processes is through the oxidation of nutrients to form energy-rich molecules of adenosine triphosphate (ATP). This process is called oxidative phosphorylation and it occurs in the mitochondria.



The energy stored in ATP can be released by hydrolysis to ADP: