Mitochondrial Biogenesis is the process by which new mitochondria are formed in the cell.

**Purpose of Mitochondria:**

The mitochondria are organelles within the cell that are responsible for the biochemical processes of respiration and ADP phosphorylation to ATP. The mitochondria metabolize both pyruvate and lactate, and are responsible for powering activities that last longer than a minute.\(^{15}\)

**Location:** The mitochondria can be found in two different places:

**Subsarcolemmal Mitochondria** reside beneath the sarcolemma. They collect oxygen from the circulating blood in the arteries, and are responsible for providing the energy needed for conserving the integrity of the sarcolemma.\(^{1,2,4}\)

**Intermyofibrilar Mitochondria** are found deeper within the cell and play a huge role in preserving enough energy for muscle contractions.\(^{1,2,4}\)
Note the different locations of the deeper intermyofibrilar mitochondria (IF) and the more superficial subsarcolemmal mitochondria (SSM) in this image.22

There are an increased number of mitochondria in tissues that require greater amounts of energy. Slow twitch fibers have high mitochondrial density while fast fibers (type IIX) have a lower density of mitochondria. This is significant because slow twitch muscles have to sustain work for longer periods of time.29

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type I (SO)</th>
<th>Type IIA (FOG)</th>
<th>Type IIX (FG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contraction time</td>
<td>Slow</td>
<td>Fast</td>
<td>Very fast</td>
</tr>
<tr>
<td>Size of motor neuron</td>
<td>Small</td>
<td>Large</td>
<td>Very large</td>
</tr>
<tr>
<td>Resistance to fatigue</td>
<td>High</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>Activity used for</td>
<td>Aerobic</td>
<td>Long term anaerobic</td>
<td>Short term anaerobic</td>
</tr>
<tr>
<td>Force production</td>
<td>Low</td>
<td>High</td>
<td>Very high</td>
</tr>
<tr>
<td>Mitochondrial density</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Capillary density</td>
<td>High</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>Oxidative capacity</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Glycolytic capacity</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Major storage fuel</td>
<td>Triglycerides</td>
<td>CP, Glycogen</td>
<td>CP, Glycogen</td>
</tr>
</tbody>
</table>
Structure:

**Inner Membrane** - freely permeable to 3 things only: water, oxygen, and carbon dioxide. Impermeable to protons.

**Cristae** - folds that increase the surface area of the inner membrane. This is where oxidative phosphorylation takes place.

**Intermembrane Space** - full of enzymes that play roles in transportation of materials

**Outer Membrane** - a phospholipid bilayer that is permeable to things such as nutrients, ATP, and ADP

**Matrix** - contains protein as well as enzymes for the Krebs cycle

See the diagram below for visual clarification of mitochondrial structure:
**Proliferation Activation:**

PGC-1α, is a protein that is a regulator of mitochondrial biogenesis. It has been established that endurance exercise is an activator for PGC-1α. Once this protein is activated, it communicates with PPAR-γ, a nuclear receptor, and then works in conjunction with numerous proteins that bind to particular DNA sequences, allowing for regulation of many processes directly associated with mitochondrial biogenesis. This topic will be covered more thoroughly in section II of this wiki: Effects of Endurance Exercise on Mitochondrial Biogenesis.

**Mitochondrial Reticulum:**

The mitochondrial reticulum describes how the mitochondria in a cell are linked together, forming a sort of network. This was first discovered by Russians Bakeeva, Chentsov, and Skulachev (1978). The abstract for the original article is below:

Mitochondrial Framework (Reticulum Mitochondriale) in Rat Diaphragm Muscle
Abstract

Reconstitution of rat diaphragm mitochondria has been carried out with the use of the serial section technique.

It is shown that mitochondrial material is organized as networks transpiercing the I band regions of the muscle near the Z-discs. Each network forms tubules, oriented perpendicular to its plane, and branches, connecting the network with mitochondrial clusters in the fiber periphery. Such a system, defined as mitochondrial reticulum, is found to be characteristic of the diaphragm of adult animals. It is absent in the diaphragm of rat embryos and new-born rats.

The junctions of the branches of mitochondrial reticulum are described. In the junction site, the outer membranes of two mitochondrial branches are in contact, and spaces between outer and inner membranes are filled with an osmiophilic substance. No junctions were found in the embryos and in newborn animals whose diaphragm contains single, elliptical or worm-like mitochondria.

The hypothesis is put forward that the mitochondrial reticulum serves as a system for transport of energy, oxygen and fatty acid residues along mitochondrial membranes over distances commensurable with the muscle fiber diameter.

There are no figures or tables for this document.

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Researchers originally believed that the mitochondria existed as single, discrete organelles, but after looking at cross sections of muscle, it is apparent that the mitochondria or its branches are present throughout different layers, or cross sections of the muscle. The image below demonstrates how in the first slide, a mitochondria was found in a specific area, as well as in the second slide. These mitochondria are linked, therefore when they are stacked on top of one another the resulting prototype looks something like the “stereo model” in the first image, or the more complex recreation in the second image.

Image 1:
What is Mitochondrial Biogenesis

Image 2:⁴
Note how many layers are present. The reticulum can be extensive depending on which type of fiber they are located in.
The mitochondria within the network experience a continuous sequence of fusion and fission. This allows the mitochondria to swap lipids, proteins, and other materials between each other, as well as remove impaired parts of the network.\textsuperscript{10,25} The diagram below offers a visual aid for the fission and fusion process:

![Diagram of mitochondrial fission and fusion](image)

More information on fission and fusion of the reticulum as well as an algebraic model of the reticulum can be found here: http://web.ebscohost.com.ezproxy.callutheran.edu/ehost/pdfviewer/pdfviewer?sid=367900df-50e8-44e5-8100-c73732d5fbb5%40sessionmgr110&vid=2&hid=114

\textbf{Gradient:}
A proton gradient exists within the mitochondria. In the electron transport chain, the stream of electrons releases energy which causes hydrogen ions to be forced into the intermembrane and intermembrane space from the matrix. The influx of hydrogen produces a lower pH in that space than in the matrix. Protons then stream down the gradient and back into the matrix thus releasing energy. This energy powers ATP synthesis. The following image gives a visual aid of the pore that is embedded in the intermembrane, and how the protons carry energy as they flow through.

**Conclusion:**

The mitochondria is a very important part of metabolism. It is important to have a basic understanding of the location, components, and function of the that drive ATP production in order to better understand the following material concerning biogenesis.