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Editorial

# Mitochondria, Brain, Heart and Body

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More and more studies revealed links amongst neurological disorders, heart diseases and cancers. For example, people with subclinical cardiovascular diseases are at higher risk for Alzheimer's disease [1], Parkinson's disease is associated with varied risk of cancer [2], Autism Spectrum Disorders and cancer have overlapping genes and molecular pathways [3, 4], heart disease and cancer share common risk factors [5], *etc*. It is intriguing how are these conditions that appear to be completely different linked together.

## A systems view

From systems biomedicine perspective, molecules, pathways, cells, organs and systems form a complex multilevel interacting network. It only makes sense to look at the human body as a whole when investigating medical conditions. That is, brain, heart and body do not work alone but function together. Therefore, in theory, it is no surprise to find the diseases linked one to another. The big question is what are their shared underlying mechanisms. Identifying the key components to their connections could provide insights to understand the pathophysiology of these diseases and help develop strategies for treatments.

## Mitochondria qualify as candidate to connect the dots

Mitochondria can be a strong candidate for such a key player that connecting these diseases. It is well known that mitochondria are involved in neurological disorders, heart diseases, and cancers. Mitochondria are associated with heart failure [6], and targeting mitochondria may provide promising outcome when treating heart diseases [7]. Mitochondria are essential for neurons and are involved in all kinds of neurological disorders such as Alzheimer's, Parkinson's and Huntington's disease, stroke, and ALS [8]. The function of mitochondria in cancers has been intensively studied. Cancer cells alter the mitochondrial bioenergetic and biosynthetic state and by manipulating the mitochondrial 'retrograde signaling' they reprogram the adjacent stromal cells to optimize the cell environment [9].

Mitochondrial dysfunction refers to impaired or defective function of mitochondria. It has been repeatedly reported to be found in heart diseases, neurological disorders and cancers [6, 10, 11, 12].

## Mitochondrial main functions: energy production and information processing

In cells, mitochondria have two main functions: supplying cellular energy and signaling. Keywords: energy (production) and information (processing). The primary role of mitochondria is the powerhouse of the cell. Mitochondria produce the cellular energy currency, Adenosine triphosphate (ATP), through respiration. As signaling organelles, mitochondria play a central role in regulating signal transduction. They control $Ca^{2+}$ homeostasis, are involved in many signaling pathways such as calcium, MAPK, PI3K-Akt, mTOR, Wnt, Ras, and insulin signaling pathways. Notably, all these signaling pathways are involved in heart diseases, neurological disorders and cancers.

Energy and information, aren't they the most two important factors to every living being? Mitochondria hold the key to understand these two matters. The consequences of mitochondrial abnormalities/dysfunction are either lack of energy or abnormal information processing which are the roots for most of the diseases.

## The future

Will mitochondria be the effective target for treating most of the diseases? It's highly possible. It's also possible that keep an eye on the healthy level of mitochondria could help preventing diseases.

As mitochondria are found in almost every cell of the human body (except the red blood cells) and are involved in many cellular activities, targeting mitochondria could have overall health improvement to the whole body, instead of limited to only one outcome. This makes the mitochondrial therapy a "whole body strategy" that would provide promising results to many multi-systems involved diseases.

Light or frequency therapy that target mitochondria could be promising for treating and preventing diseases. Research has shown that light therapy can contribute to the treatment of various condition including cancer [13], traumatic brain injury [14], and heart conditions [15, 16].

A study tested flashing light therapy (in regard to gamma oscillations) in a mouse model of Alzheimer's disease and had outstanding outcomes [17]. Note that gamma oscillations in hippocampus require strong functional performance of mitochondria [18]. In addition to brain, there are pieces of evidence show that light or frequency therapy have effects on mitochondria in muscle cells and cancer cells [19, 20].

Future studies that focus on light and frequency therapies targeting mitochondria should play important roles in the development of next-generation medical treatment.

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