# CBD Science: How Cannabinoids Work at the Cellular Level to Keep You Healthy

*By Adrian Devitt-Lee / Project CBD*



## What are mitochondria?

Mitochondria are universal energy adaptors that exist in the cells of every multicellular organism, including humans. The number of mitochondria in an individual cell can vary greatly depending on the organism and tissue type. (All human cells, except for red blood cells, contain mitochondria.) One of the main functions of mitochondria is to take high-energy molecules – such as sugars and amino acids – and convert them into a form of energy, called adenosine triphosphate (ATP), which the cell can use.

## For the cell, ATP is like a battery.

The process of extracting small bits of energy from high-energy molecules can be quite dangerous. Imagine trying to power a car by simply lighting the fuel tank on fire. A cell can't handle the microscopic equivalent of an explosion, so the cell must use finesse to harness this energy. Individual electrons are extracted from high-energy molecules by a process known as cellular respiration and their energy is gradually released.

This gradual release of individual electrons allows the cell to synthesize ATP from its precursors, adenosine diphosphate (ADP) and inorganic phosphate (Pi). The cleavage of ATP back into ADP and Pi releases a small amount of energy, which powers the proteins that allow each cell to function and communicate. ATP is the main energy source for the majority of cellular functions. While commonly referred to as the cell's powerhouse,

mitochondria are also involved in other metabolism-related functions, but the goal is always the same -- homeostasis, the maintenance of a stable internal environment despite external fluctuations.

## Symbiosis

Originally, mitochondria were separate from other cells. At some point, one-and-a-half to two billion years ago, a cell engulfed an evolutionary precursor to a mitochondrion. But instead of digesting the mitochondrion, the two living entities formed a symbiotic relationship. The host cell would provide nutrients and a safe place for the mitochondrion to exist, and the mitochondrion would perform the dangerous process of cellular respiration, giving the host a more useable form of energy. The result was so evolutionarily fundamental that this symbiotic relationship preceded the occurrence of multicellular organisms. All plants, animals and fungi are endowed with mitochondria.

This theory of how two different self-organized living systems began to collaborate symbiotically is supported by the fact that mitochondria have retained their own genome that is separate from the host cell's DNA. Mitochondria and the host cell replicate independently; they also have separate cellular membranes. Two other organelles are thought to have developed in a similar way: the chloroplast, which enables photosynthesis in plants, and the nucleus, which holds the cellular DNA and acts as a kind of coordinator of the cell.

Mitochondrial diseases can be caused by inherited mutations in mitochondrial DNA or defects in the nuclear genes that encode proteins that regulate mitochondrial division and DNA replication. Mitochondrial disorders can also develop due to the adverse effects of drugs, infections, environmental toxins or unhealthy lifestyle habits. Mitochondrial diseases are most severe when the defective mitochondria are present in muscle, brain or nerve tissue, as these cells require more energy (and hence more mitochondrial activity).

## Free radicals & phytocannabinoids

Although mitochondria allow energy to be accessed at a measured pace in relatively small quantities, the process of cellular respiration, whereby cells extract energy from nutrients, still can be damaging. High-energy electrons offload their energy in a multitude of complicated steps, until the lower-energy electron is finally released onto an oxygen molecule. Ideally, the oxygen molecule will interact with hydrogen and form water, which is very stable.