THE POWER OF YOUR BODY

THE POWER OF YOUR BODY

How to Boost Mitochondrial Energy and live a healthy, fulfilling life

Al. J Gensini

ELSEWHERE
publishing house
There is a world elsewhere

Published by Elsewhere Publishing House
First Edition: 2026
Author: Al. J Gensini

ELSEWHERE publishing house
There is a world elsewhere

Table of Contents

Foreword

The human body is one of the most extraordinary biological machines nature has ever produced. Every single second, deep within our cells, billions of chemical reactions take place that allow us to live, think, move, and love. Yet, for most of our time, we are completely unaware of this invisible and silent orchestra.

At the heart of this orchestra are the mitochondria. These small organelles, present in every one of our nucleated cells, have the most important task of all: transforming the food we eat and the oxygen we breathe into usable energy, adenosine triphosphate, or ATP. Without mitochondria, there would be no complex life as we know it. Without healthy and efficient mitochondria, there is no health.

This book stems from a deep conviction: health and longevity are not the result of chance or merely fortunate genes, but depend to a very large extent on the quality and quantity of energy our body is capable of producing. An efficient mitochondrion means a muscle that responds, a brain that thinks clearly, a vigilant immune system, a heart that pumps without tiring, and radiant skin. A dysfunctional mitochondrion, on the other hand, is at the root of most of the chronic diseases of our time: type 2 diabetes, neurodegenerative diseases, metabolic syndrome, chronic fatigue, premature aging, and frailty.

In the following pages, you will find two distinct yet closely related sections. The first is theoretical: a journey through cellular biochemistry, the Krebs cycle, the electron transport chain, oxidative phosphorylation, and mitochondrial biogenesis. Don't worry: I've tried to explain technical concepts clearly, without oversimplifying them. Understanding how the engine works is the first step toward learning how to tune it.

The second section is practical: here you'll find concrete tools—related to diet, exercise, and lifestyle—to truly boost your mitochondria, increase ATP production, reduce oxidative stress, and, ultimately, live better and longer.

All scientific claims presented in this book are supported by actual bibliographic references, published in peer-reviewed journals and indexed on PubMed. The complete bibliography is at the end of the book.

My hope is that this book will guide you on a transformative journey, where every meal, every workout, and every night's sleep become conscious choices, aimed at boosting the primary source of your health: mitochondrial energy.

Enjoy the read, and happy boosting.

Introduction

Imagine for a moment that you have, inside you, about forty billion billion tiny power generators. This is not an exaggeration: it is the estimate, calculated by cell biologists, of the total number of mitochondria present in the body of an adult human. Forty quintillion microscopic organelles, each between 0.5 and 1 micrometer in size, that day and night produce the energy needed to make the heart beat, move the muscles, power the brain, repair tissues, and fight infections.

The numerical result of this work is staggering. Every day, a healthy adult produces and consumes an amount of ATP—the universal energy molecule—equivalent, by mass, to their own body weight. A person weighing seventy kilograms produces and reuses approximately seventy kilograms of ATP every day. This extraordinary fact alone should make us reflect on the crucial importance of these organelles.

Unfortunately, modern medicine and popular health culture have taken a long time to recognize the centrality of mitochondria. For decades, attention has been focused on macroscopic organs, hormonal systems, vitamins, and fad diets. Only in the last twenty-five years, thanks to the work of researchers such as Peter Mitchell, Douglas Wallace, Nick Lane, Bruce Spiegelman, Leonard Guarente, Gerald Shadel, and many others, has the fundamental role of mitochondria in health, disease, and aging become the subject of systematic and rigorous study.

Today we know that mitochondria are not merely "powerhouses." They are multifunctional organelles that regulate programmed cell death (apoptosis), participate in the synthesis of steroid hormones, control intracellular calcium homeostasis, produce and manage reactive oxygen species (ROS) also used as signaling molecules, and communicate with the nucleus through complex retrograde signaling circuits. A mitochondrion is, in essence, a small decision-making center that helps determine whether that cell should continue to live, divide, or die.

When mitochondria are functioning at peak efficiency, we experience energy, mental clarity, endurance, a good mood, and the ability to recover. When they begin to become less efficient—due to age, an unbalanced diet, physical inactivity, chronic stress, sleep deprivation, or exposure to toxins—the first symptoms of dysfunction emerge: persistent fatigue, cognitive fog, insulin resistance, exercise intolerance, accumulation of visceral fat, and low-grade chronic inflammation. Over time, these dysfunctions become fertile ground for major chronic diseases: type 2 diabetes, cardiovascular disease, cancer, and dementia.

The good news is that, contrary to what was believed until a few decades ago, mitochondria are not static organelles. They are dynamic, plastic, and capable of adapting to the signals we send them. We can increase their number (mitochondrial biogenesis), improve their quality (selective mitophagy), and optimize their function (energy coupling efficiency). We can do this with simple, inexpensive tools available to everyone: the food we choose, the way we move, how we sleep, how we manage stress, and how we utilize—at times—the controlled challenges of hormesis.

This book is a roadmap. In the first part, we will explore, with the rigor of biochemistry, how the engine works: from glucose to pyruvate, from pyruvate to the Krebs cycle, from the Krebs cycle to the respiratory chain, from the respiratory chain to ATP synthesis. In the second part, we will provide you with concrete tools to optimize every single step.

Let's begin.

Part One
Theory of Cellular Energy

Chapter 1

The Cell and Mitochondria: Anatomy of a Power Plant

To understand how we function, we need to zoom in. Our body is composed of approximately thirty to forty trillion cells. Each cell, in turn, contains a variable number of mitochondria: from a few dozen in a lymphocyte to thousands in a cardiomyocyte, up to tens of thousands in a large neuron or a liver cell. Mitochondria are, in other words, distributed unevenly: where energy is needed most, there are more of them.

The heart is the most extreme example. Cardiac muscle cells devote approximately 35–40% of their internal volume to mitochondria. This is no coincidence: the heart beats an average of 100,000 times a day, throughout a person's entire life, without pause. This requires an uninterrupted supply of ATP, which only an extremely high mitochondrial density can guarantee. Skeletal muscle, the liver, the kidneys, and the brain also have very high mitochondrial densities. At the opposite extreme, red blood cells are the only cells in our body without mitochondria: they produce energy solely through anaerobic glycolysis, an evolutionary choice that maximizes the internal space dedicated to hemoglobin.

The Structure of the Mitochondrion

A mitochondrion is an organelle with a double membrane. This seemingly trivial characteristic is, in fact, the secret to its efficiency and its extraordinary ability to produce energy.

The outer membrane is relatively permeable, thanks to the presence of porins (protein channels) that allow the free passage of molecules with a molecular weight of less than 5,000 daltons. The inner membrane, on the other hand, is extremely selective: it allows only specific molecules to pass through, via dedicated transporters. It is on this inner membrane, folded into numerous cristae, that the protein complexes of the electron transport chain and ATP synthase are anchored.

The space between the two membranes—the intermembrane space—is a crucial compartment: this is where protons (H^+) pumped by the respiratory complexes accumulate, creating the electrochemical gradient that will then be used to synthesize ATP. The matrix, enclosed by the inner membrane, is where the Krebs cycle, β-oxidation of fatty acids, heme synthesis, portions of the urea cycle, and numerous other reactions take place.

The cristae: a surface dedicated to energy

The folds of the inner membrane, called cristae, are not random. Their morphology is finely regulated and varies according to cellular metabolism: highly active cells have mitochondria with dense, lamellar cristae, while cells in a state of low metabolism exhibit mitochondria with sparser cristae. A healthy adult has approximately 500 square meters of total mitochondrial cristae surface area—roughly the area of two tennis courts. It is on this enormous molecular surface that most of our body's energy is produced.

The curvature of the cristae is stabilized by a protein complex called MICOS (Mitochondrial Contact site and Cristae Organizing System) and by OPA1 proteins, which maintain the "neck" connecting the inner membrane and the cristae. When MICOS or OPA1 are damaged, the cristae become disorganized and the efficiency of the entire respiratory chain collapses. It is no surprise that defects in these components are associated with numerous mitochondrial, neuromuscular, and ophthalmological disorders.

The mitochondrial genome: a maternal inheritance

Each mitochondrion possesses its own DNA, distinct from nuclear DNA. Human mitochondrial DNA (mtDNA) is a small circular molecule of 16,569 base pairs, encoding 37 genes: 13 proteins, all belonging to the respiratory chain complexes, 22 tRNAs, and 2 rRNAs. All other approximately 1,500 protein products required by the mitochondrion are encoded by nuclear genes, synthesized in the cytoplasm, and then imported.

mtDNA has some unique characteristics. It is transmitted almost exclusively through the maternal line: at the moment of fertilization, the sperm contributes the nucleus, but its few mitochondria are selectively degraded. This means that we all share our mitochondria with our mother, our maternal grandmother, our grandmother's mother, and so on back to the famous "mitochondrial Eve" who lived about 150,000 years ago. It is a genetic thread that connects every living human being.

mtDNA is also particularly vulnerable to oxidative damage. Being anchored to the inner membrane, it is very close to the site of production of reactive oxygen species (ROS), and is not protected by histones like nuclear DNA. The mutation rate in mtDNA is ten to twenty times higher than that of nuclear DNA. The accumulation of mutations in mtDNA over the course of a lifetime is one of the proposed mechanisms underlying cellular aging.

Chapter 2

The Evolutionary Origin and Symbiotic Nature of Mitochondria

One of the most fascinating ideas in modern biology is that mitochondria are not native components of eukaryotic cells, but descendants of ancient bacteria that, approximately two billion years ago, established a stable symbiotic relationship with a host cell. This is the endosymbiotic theory, fully proposed by Lynn Margulis in the 1960s and now supported by a vast body of genetic, morphological, and biochemical evidence.

The evidence is abundant: mitochondria possess their own circular genome, similar to that of bacteria; they reproduce by binary fission, just like bacteria; they possess 70S ribosomes, characteristic of prokaryotes; they synthesize their own proteins autonomously (at least in part); they have a double membrane—the inner one is considered the original "bacterial membrane," while the outer one derives from the host cell's endocytic membrane. Phylogenetic analysis shows that their closest ancestor belongs to the group of α-proteobacteria, specifically to organisms similar to Rickettsia.

This event—the symbiotic involvement of a bacterium capable of using oxygen to produce large amounts of ATP within an anaerobic cell—is considered one of the most important milestones in the history of life on Earth. According to Nick Lane and William Martin, it was precisely the availability of enormous amounts of energy per gene, made possible by mitochondria, that allowed for the evolution of eukaryotic complexity: larger cells, larger genomes, tissue specialization, and multicellularity.

Why this origin is important for our health

Understanding that mitochondria are, in a sense, semi-independent organisms within us helps explain many aspects of our biology. mtDNA, like bacterial DNA, is recognized by our innate immune system when it is released into the bloodstream following cellular damage. This triggers a powerful inflammatory response, mediated by receptors such as TLR9 and cGAS-STING, which recognize unmethylated CpG motifs typical of bacterial DNA. It is no coincidence that circulating mtDNA is now considered an important marker of chronic inflammation and aging (inflammaging).

Another practical point: when we treat a bacterial infection with antibiotics, many of these drugs—such as chloramphenicol, tetracyclines, and aminoglycosides—inhibit protein synthesis in bacterial 70S ribosomes. But our mitochondria have 70S ribosomes. This explains why chronic or massive use of certain antibiotics can cause mitochondrial side effects—fatigue, muscle pain, organ toxicity—and why the health of the gut microbiota is so closely linked to the health of our mitochondria.