MitoLongevity

The Secret to Fueling
a Life Time of Good Health

Dr. Chris D. Meletis

www.MitoLongevity.com
www.DrMeletis.com

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Dedication

Special thanks to my wife of 28 years, without your support and love, this and all my other books would not have been possible.

A big thank you to the MitoQ team for their support and shared mission to educate and enlighten humanity to protect and nurture mitochondria function in pursuit of whole-body wellness for one and all.

Lastly, but not least, a nod to the intentional design of the human body and its built-in resilience.

And my gratitude to all that share the common educational mission to elevate and liberate our brothers and sisters of the human race that need that additional support, love, and knowledge to flourish.

Contents

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Foreword

It is a privilege to write this foreword for my esteemed colleague for this great work.

Mitochondrial health is the future of medicine.

I predict addressing mitochondrial dysfunction will be a widespread cornerstone of clinical practice in the coming years.

When reading through Chris' book, the reader quickly realizes the mitochondria is much more than the "powerhouse of the cell," as we learned in grade school.

Along with producing energy in the form of adenine triphosphate (ATP), the mitochondrion is also involved in protecting the cell against oxidative stress and, when functioning optimally, slows down the aging process.

MitoLongevity- The Secret to Fueling a Life Time of Good Health delineates the reason's why and how mitochondrial health matters, identifies the root cause, and empowers the reader to optimize the health of this organelle with specific instruction. Furthermore, the material hereto addresses explicitly the nuances of mitochondrial related disorders often disguised with diagnoses of chronic pain and fatigue, exercise intolerance, and even cancer.

Unlike most of the information you read online on mitochondrial health and dysfunction, this book grounds itself in evidence and firmly positions itself on the side of science.

This treasured resource takes you on a journey where Chris discloses the diseases and common ailments associated with reduced mitochondrial health. He astutely helps the reader learn why people often feel a little off, fatigued, foggy minded, and at risk of chronic disease.

Rather than leave you in limbo without a solution, towards the latter part of his book, he shares lifestyle practices and critical nutrients that help prevent and overcome mitochondrial damage.

One of those significant nutrients of interest is a novel form of Coenzyme Q10 (CoQ10), MitoQ®

In Chapter 7, Chris lays out the impressive science behind MitoQ® in improving heart, liver, and brain health and helping people day-to-day ailments such as chronic fatigue.

The valuable advice you'll receive in this text is factual, safe, and ready for use. I applaud Chris for his ability to reduce the complex concepts of mitochondrial health into a framework of simplicity and clarity that's unmatched.

This book is an asset for all of us – practitioners and lay readers alike.

It's about time such a resource exists.

I invite you to read, apply, and enjoy optimal health.

Dr. Geo Espinosa, ND, L.Ac, IFMCP
Clinical Professor, NYU Langone Health
Department of Urology

Chapter One

The Mighty Mitochondria

Scientists are finding that virtually every health condition—likely including the ones you're suffering from now—are caused or worsened by one factor. What is that factor? The inability of tiny cellular powerhouses called mitochondria to work properly.

Imagine if you're holding a flashlight and the battery dies. The flashlight stops working. Mitochondria are to your cells what the battery is to that flashlight. In other words, they produce what I like to call mitotricity in the same way that power plants produce electricity. When mitochondria aren't working like they're supposed to, your cells are under-fueled. Fatigue settles in, and your body suffers from any number of diseases. Or, you're simply too exhausted to feel your best.

That's why boosting the health of your mitochondria can help you have more energy and stay healthier. Helping your mitochondria stay healthy means that you're more likely to stay healthy, too. In my clinical practice, I often find that patients do remarkably better when their treatment includes rejuvenating mitochondrial health.

I have become fascinated by these little cellular components. They're one of your body's most amazing features. The 50 to 100 trillion cells in the body all need the energy to fuel their various functions. The mitochondria

are the powerhouses of the cells. They provide each of the 50 to 100 trillion cells with the energy needed to thrive. That's quite a task! Imagine if you had to supervise 50 to 100 trillion employees to make sure each of them is doing their job properly.

How Mitochondria Produce Mitotricity

The energy that mitochondria produce is called adenosine triphosphate—ATP for short. ATP is to the cells of your body what gasoline is to your car. It's the fuel your cells use to operate. To make this fuel, mitochondria burn down digested food using the oxygen we breathe. Your mitochondria use oxygen to produce this important energy molecule—its fuel—in one of several ways. Each of these ATP-producing processes have highly technical names—the citric acid cycle (sometimes known as the Kreb's Cycle), oxidative phosphorylation, and beta-oxidation. Just remember that these processes are like the fuel pump at the gas station. They create the fuel—the ATP—that drives your body.

The citric acid cycle makes ATP out of carbohydrates, fats, and proteins. Beta-oxidation breaks down fatty acids, leading to the generation of ATP. Oxidative phosphorylation—OXPHOS for short—is the process by which cells use enzymes to break down nutrients, ultimately producing ATP. OXPHOS creates more than 90% of all the cellular energy in your body. It's also the major source within cells of harmful reactive oxygen species or ROS for short.

A key player in oxidative phosphorylation is the electron transport chain, which helps with the production of ATP. In fact, most ATP in your body is produced thanks to the electron transport chain. There are four parts to the electron transport chain: Complex I, II, III, and IV, along with ATP Synthase. If any of these complexes aren't working properly, your mitochondria will either weaken or begin to multiply in an abnormal way. Chances are good you'll feel fatigued, or your overall health will suffer.

Because these ATP-producing factors need oxygen to work properly, they're called aerobic respiration. Aerobic means in the presence of oxygen.

Starting with ATP and ending with and including glycolysis. Glycolysis makes ATP out of the sugar glucose. This can be either an aerobic (using oxygen) or a non-aerobic process.

When oxygen isn't present in the cells, another ATP-producing process called fermentation takes place. Fermentation is less efficient at converting the energy from glucose into ATP. In fact, fermentation of glucose gives birth to only 2 ATP molecules. Compare this with the 38 ATP generated from the aerobic respiration of glucose.

Your body is always hard at work to manufacture the fuel it needs to function. Daily, the human body recycles the equivalent of its own weight in ATP.[1]

In making ATP, the mitochondria must get rid of several waste products. dioxide, you can eventually exhale. Water is another waste product. We can urinate this out of the body. Free radicals are the third waste product of ATP production. These aren't always as easy to dump as the other two waste products. Free radicals are chemicals that when produced in large numbers are extremely damaging to the mitochondria and to the body itself. The shape of the mitochondria is linked to the number of free radicals produced.[2] Healthy mitochondria are tubular. However, they become donut-shaped under the stress of too many free radicals. When the damage can't be undone the mitochondria are blob-shaped. A vicious cycle is created where the more a mitochondria's shape departs from normal, the more free radicals are made, which in turn leads to more mitochondrial damage.[2]

When your mitochondria aren't working properly, it spells trouble for the body. This leaves you vulnerable to any one or more diseases. And this, too, is a vicious circle. Mitochondria dysfunction can lead to the development of disease. At the same time the disease, itself, can result in

mitochondrial dysfunction. In fact, in one way or another, virtually every disease is linked to damaged mitochondria. We'll talk more about this in later chapters.

What Causes Mitochondrial Damage?

There are many reasons why your mitochondria stop working properly. Genetics can play a role. For example, if your mother was older when she gave birth to you, you're more likely to have mitochondrial DNA with mutations.[3]

Even healthy mothers can pass on unhealthy mitochondria to their children. In fact, egg cells in healthy women often may all have a few defects in their mitochondrial DNA, which are passed on to the unborn baby.[4] Because of the small number of mitochondria in developing cells, there aren't always enough healthy mitochondria to silence the unhealthy ones.[4] In this case, the baby is born with unhealthy mitochondria even though the mother was healthy.[4]

However, genetics load the gun but diet, lifestyle, and environmental factors pull the trigger. Here are some of the factors that actually pull that trigger.

Medications that Damage the Mitochondria

First of all, many over-the-counter and prescription medications cause mitochondrial damage. For example, statin drugs used to lower cholesterol are toxic to mitochondria.[5] In cell culture and human studies of people treated with statins, these drugs interfered with an important part of mitochondrial function.[5] In fact, the muscle problems that are a side effect of statins are very likely due to the harm these drugs inflict on the mitochondria.[5,6] And another known side effect of statins—an increased risk of prediabetes and diabetes—is related in part to mitochondrial damage.[7]

See the table below to find out which medications are the biggest culprits in damaging mitochondria.

Medications That Cause Mitochondrial Damage[8]

- Aspirin
- Acetaminophen (Tylenol®)
- Naproxen (Alleve®)
- Anesthetics (lidocaine, propofol)
- Angina medications such as Perhexiline, amiodarone (Cordarone®), and Diethylaminoethoxyhexesterol (DEAEH)
- Antibiotics (tetracycline, antimycin A)
- Antidepressants such as amitriptyline (Lentizol®), amoxapine (Asendis®), citalopram (Cipramil®), fluoxetine (Prozac®), Symbyax, Sarafem, Fontex, Foxetin, Ladose, Fluctin, Prodep, Fludac, Oxetin, Seronil, and Lovan.
- Anti-anxiety pharmaceuticals including Alprazolam (Xanax®), diazepam (valium, diastat)
- Barbiturates such as Amobarbital (Amytal®), aprobarbital, butabarbital, butalbital (Fiorinal®), hexobarbital (Sombulex®), methylphenobarbital (Mebaral®), pentobarbital (Nembutal®), phenobarbital (Luminal®), primidone, propofol, secobarbital (Seconal®), Talbutal®), thiobarbita
- Statin drugs (Pharmaceuticals used to lower cholesterol) including atorvastatin (Lipitor®, Torvast®), fluvastatin (Lescol®), lovastatin (Mevacor®),pitavastatin

(Livalo®, Pitava®), pravastatin (Pravachol®, Selektine®, Lipostat®), rosuvastatin (Crestor®), simvastatin (Zocor®, Lipex®)

- Cholesterol medications that reduce bile acids such as cholestyramine (Questran®), clofibrate (Atromid-S®), ciprofibrate (Modalim®), colestipol (Colestid®), and colesevelam (Welchol®).
- Dementia medications including tacrine (Cognex®) and Galantamine (Reminyl®).
- Diabetes medications such as metformin (Fortamet®, Glucophage®, Glucophage XR®, Riomet®), troglitazone, rosiglitazone, and buformin.
- HIV/AIDs medications such as Atripla®, Combivir®, Emtriva®, Epivir® (abacavir sulfate), Epzicom, Hivid® (ddC, zalcitabine), Retrovir® (AZT, ZDV, zidovudine), Trizivir®, Truvada®, Videx® (ddI, didanosine), Videx® EC, Viread®, Zerit® (d4T, stavudine), Ziagen®, Racivir.®
- Epilepsy and seizure medications including valproic acid (Depacon®, Depakene®, Depakene syrup, Depakote®, depakote ER, depakote sprinkle, divalproex sodium).
- Lithium (used for mood disorders such as bipolar disorder).
- Parkinson's disease pharmaceuticals such as Tolcapone (Tasmar®, Entacapone (COMTan®, the combination drug Stalevo®).

Environmental Toxins

Daily, our bodies are assaulted by pesticides, herbicides, air pollutants, and other toxins. This does not bode well for the mitochondria. Exposure to each of these harmful substances results in your mitochondria producing too many ROS,[9,10] a process known as oxidative stress. Some oxidative stress is normal and necessary. But too much can cause disease. When mitochondrial DNA comes in contact with ROS, compounds may be created that trigger genetic mutations that can lead to mitochondrial disease.[11]

Pesticides can also damage the structure of the mitochondria, causing ATP production to plummet. Scientists believe this could be the means by which pesticides cause Parkinson's disease.[10]

Aging

During aging, blood flow decreases, and little by little, the brain receives less blood and, therefore, less glucose and oxygen for mitochondria to use to make ATP. Eventually, brain mitochondria are under fueled, and brain cells are damaged beyond repair, leading to dementia.[12] Scientists have debated two questions. Does the mitochondrial damage that happens as you grow older actually *cause* aging? Or is mitochondrial dysfunction a consequence *of* aging? There's evidence for both arguments. In all probability, both are true. But the bottom line is that mitochondria are key players in complicated processes that lead to cell death. Mitochondria are the caretakers of the cells in almost every tissue in your body. As such, they are involved in every aspect of aging, including inflammation and cell death.[13]

Scientists have found that in aged tissue, mitochondrial function declines.[14] As you grow older, your mitochondria produce less ATP[15]—less fuel for you to rumble along on this journey called life. As mitochondria grow older, they produce more than the normal amount of ROS.[14] One theory of why we age is that ROS builds up in cells, organs, and organisms cause damage over time.

The parts of your body most affected when aging mitochondria have problems performing their duties are the tissues that need the most energy.[14] So your heart and skeletal muscle (muscles attached to your bones) pay the greatest price. With age, skeletal muscle breaks down—a condition known as sarcopenia—leading to weakened muscle strength. Many changes happen in the muscles with age: reduced muscle mass and quality, replacing muscle fibers with fat, and increased fibrosis, the thickening, and scarring of connective tissue. Mitochondrial dysfunction is partly to blame for these age-related changes to muscles.[14,15]

Even your fat tissue is affected by aged mitochondria.[14] Fat tissue regulates the way your body stores energy, and it influences the number of calories a person needs to carry out physical activities such as exercise, breathing, and digesting food. Fat tissue also releases molecules known as adipokines that send messages to organs including the heart and skeletal muscle. Adipokines are like emails sent to the inboxes of your organs, giving them important information on how to be healthy. Mitochondria are the main site of ATP production in fat cells.[14,16] Therefore, it's especially important that mitochondria in fat cells function properly.

When the mitochondria don't function properly, fats are deposited in skeletal muscle or heart cells, liver cells, or beta cells in the pancreas, which make the blood-sugar-lowering hormone insulin.[17] This can lead to toxic effects such as heart problems or the body's ignoring of important signals sent by the blood-sugar lowering hormone insulin.[17] It becomes a vicious cycle. Mitochondria in fat cells don't work properly, leading to an accumulation of fat around the body. And that buildup of fat leads to more problems with the mitochondria. In fact, mitochondria numbers plummet in people who are obese.[18]

During aging, mitochondria also stop working as well as they used to in the gastrointestinal tract—and this dysfunction can wreak havoc on your gut microbiota or microbiome, the communities of bacteria (both good and bad) and other small organisms that live in your gut. Researchers investigated whether the mitochondrial function is weakened in the colon

lining of aging mice and whether exercise can prevent the damage to the microbiota that occurs during age-related mitochondrial dysfunction.[19] They found that mitochondrial dysfunction was linked to changes in the gut microbiota during aging. What's more, aerobic exercise reduced some of these changes. This link between the mitochondria and the microbiota has led to the coining of the word mitobiome.

The bottom line? Your mitochondria need all the help they can get as you grow older.

Your Stressed-Out Mitochondria

In order to cope with stress, your body needs energy—and lots of it. Mitochondria help produce the energy your body needs to keep it from succumbing to the harmful effects of stress. What's more, the mitochondria produce and metabolize stress hormones. Scientists confirmed that the mitochondria could influence reactions to stress in an experiment where they manipulated mitochondrial function in animals.[20] The result? Changing the function of the mitochondria also changed the way the animals responded to stress. But stress can also weaken the mitochondria. Stress is associated with mitochondrial changes similar to those that happen during aging.[21] For example, stress tends to take its toll on intestinal health. Research shows that mitochondrial dysfunction plays a big role in the damage that stress does to the gut.[22] Mental stress interferes with mitochondrial function in the gut and weakens complex 1 activity of the mitochondria electron transport chain.[22]

In the central nervous system, small amounts of stress hormones give the mitochondria a beneficial boost. These hormones also help with learning, memory, and a process known as neurotransmission, which is involved in mental health.[23] Neurotransmitters are brain chemicals that help cells talk to each other. Larger amounts of stress hormones, on the other hand, block mitochondrial activity and interfere with neurotransmission and mental function.[23]

Mitochondria are linked to mental health in other ways. Studies show that mitochondrial function and structure is changed in areas of the brain that are characterized by abnormalities such as bipolar disorder, major depressive disorders, schizophrenia, and Alzheimer's disease.[24-26]

Exposure to chronic stress when you're younger increases the risk of mitochondria not working properly as you age, especially if steps aren't taken to rejuvenate these important cell structures.[27] We'll talk more about those steps later in this book. Researchers detected low mitochondrial numbers in people who experienced chronic stress in their early years and were now suffering from depression, anxiety, and substance use disorders.[27] The mitochondrial problems in these individuals were associated with reduced length of telomeres—caps on the ends of chromosomes that become shorter with age.[27] Telomerase, the enzyme in charge of maintaining telomere length, plays a role in mitochondrial activity.[28] This means that an enzyme important in aging also is involved in mitochondrial health.

Further proof that stress damages the mitochondria came in the form of a study that looked into how unborn children were impacted by their mother's stress levels.[29] In this study, if a pregnant mother experienced emotional stress, it can affect the mitochondria in the placenta of the fetus.

Your Mitochondria Are What You Eat

The type of foods you put into your body also impact your mitochondria's health—and that of your children. Take high-fructose corn syrup, for example. When rats ate a high-fructose diet during pregnancy and breastfeeding, their offspring's brain mitochondria didn't work right later in life.[30] Children of the fructose-fed mothers also weighed significantly less throughout life.

High-fructose corn syrup can overwhelm the mitochondria in the liver.[31] This stops the liver from doing its job of processing glucose and insulin.

But it's not only high-fructose corn syrup that damages the mitochondria. Table sugar has the same effect.[32] When you eat pure crystalline sugar

and/or high-fructose corn syrup, your body can't keep up with what it needs to do to protect against all the damage that occurs when you eat that slice of cake or pie or sip that milkshake. Eating these types of sweeteners causes a spike in blood sugar and insulin levels, as well as the harmful process known as oxidative stress.[32] When we eat added sugar, we're putting into our bodies something that even some researchers admit isn't really a food at all.[32]

Compare this to eating a slice of fresh fruit, which has fiber, vitamins, minerals, and phytonutrients that can stop the excess oxidative stress triggered by the small amount of fructose present in the fruit.[33] Eating what's called a ketogenic diet (similar to the popular Atkins diet) of more meat and fewer carbohydrates also protects the mitochondria from damage.[33] And it leads to the creation of more mitochondria.[33]

Olive oil, an important part of a Mediterranean diet, also helps protect the mitochondria from damage.[34,35] In addition, fish is an important part of the Mediterranean diet. The omega-3 fatty acid DHA, found in fish, stops the mitochondria from producing too many ROS.[36] Your mitochondria need to produce some ROS, but when they make too many, it can cause serious damage.

Oxygen Deprivation

Ironically, even though we're surrounded by oxygen, many of us aren't getting enough of it. Sleep apnea (a condition where a person stops breathing from time to time during the night), aging, stress, secondhand smoke, drinking too much alcohol, weight gain, and too much or too little exercise can all rob your body of oxygen. When the body isn't getting enough oxygen, it takes its toll on the mitochondria. Studies have shown that low oxygen causes an increase in oxidative stress and weakens the mitochondria's ability to do their job. It stops them from producing enough ATP.[37]

However, in both people who don't get a lot of exercise and in athletes, exercise even in a low oxygen environment (such as high altitude) can

give the mitochondria a helping hand. In athletes, training at high-altitude where there isn't much oxygen can help their mitochondria work better over the long term and improve the body's ability to produce and use ATP.[38] The mitochondria adapt to the low-oxygen environment, and this adaptation helps athletes perform better.[38]

Hormone Imbalances

Hormone imbalances can spell bad news for the mitochondria. The mitochondria are the birthplace for all hormones.[39,40] In the mitochondria, cholesterol is changed into the hormone pregnenolone, the mother of all steroid hormones.[39,40] What's more, an important part of mitochondrial function known as the electron transport chain plays a role in making testosterone.[41] Estrogens and male hormones protect the mitochondria from damage, so imbalances in these hormones can lead to mitochondrial fatigue.[42] Mitochondria need estrogen to work properly, and this hormone is also important to the creation of new mitochondria.[43-45]

Carrying The Damage Forward to Your Kids and Grandkids

When your mitochondria are damaged by any of the factors mentioned above, it's not only your health that's impacted. Your children and grandchildren are affected, too.[46,47] Mitochondrial damage can be passed on to the next generation not only through genetics but also in a process known as epigenetics.[46,47] Exposure to a toxin or any other mitochondria-damaging factor mentioned above can cause epigenetics to kick in. This process causes genes to switch on and off. Often, what's turned on or off isn't beneficial to the body. Epigenetic changes to mitochondrial DNA may be to blame for the development of many diseases.[48]

The takeaway lesson from this chapter? Anything that harms your mitochondria can cause long-lasting damage to your body and lead to disease. In the next chapter, I'll discuss exactly which diseases are linked to mitochondria not working their best.

Amazing Mitochondrial Facts

- Mitochondria are the gatekeepers of cell life and cell death.
- You inherit your mitochondria from your mothers, though there is some emerging evidence that a very minuscule amount may arise from your father yet not as a rule.
- Cells that need a lot of energy to accomplish their tasks have more mitochondria, such as those found in skeletal and heart muscle and the liver and brain.
- Nerve cells that make up the cortex of the brain, when they're at rest, consume 4.7 billion ATP molecules per second.[49]
- A resting human brain uses about 13 pounds of ATP molecules daily.[12]
- Many single cells can contain from 200 to 2,000 mitochondria. Sperm cells contain only 16 mitochondria. Ovarian cells known as oocytes have up to 100,000.
- When your body needs more energy, your mitochondria can multiply by becoming larger and then dividing.
- Mitochondria have lots of folds on their inner membrane. These are called cristae. These folds boost the surface area of the inner membrane, which helps the mitochondria work better and produce more energy.
- Soldiers with Gulf War Illness are more likely to have damaged mitochondria.
- Your mitochondria have their own DNA (mtDNA). You get this DNA from your mother, with rare exception.

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