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Exploring the Miraculous World of Mitochondria

Analysis by Dr. Joseph Mercola | September 01, 2024

STORY AT-A-GLANCE

- In my interview with renowned mitochondrial researcher Hemal Patel, we discuss that mitochondria are crucial for overall health, as impaired mitochondrial function lies at the heart of most chronic diseases
- The intimate connection between mitochondria and the cell membrane, especially specialized microdomains called caveolae, is crucial for regulating oxygen delivery and metabolism
- Your gut microbiome and mitochondria have a two-way communication, with microbial metabolites impacting mitochondrial function and vice versa, offering potential for disease prediction and prevention
- Collaboration between mitochondrial biology, gut health and personalized medicine holds promise for unlocking vibrant, lasting wellness by addressing the root causes of chronic disease

As an advocate for the crucial role of mitochondrial health in overall wellness, I was thrilled to have the opportunity to sit down with renowned mitochondrial researcher Hemal Patel, a professor in biology at the University of California in San Diego.

We discussed the latest breakthroughs in our understanding of these remarkable cellular powerhouses, as well as the fascinating connection between mitochondrial function and the gut microbiome. Patel and I share the view that impaired mitochondrial function lies at the heart of most chronic diseases. As he stated:[1]

> *"People tend to think of mitochondria as involved in longevity, which is healthy aging. But there are [many] other things that people think are involved as well, which may or may not be important … where the pendulum is shifting is it's really about the mitochondria at the end of the day. If you don't have those, and if you're not making good energy, none of those other factors matter at the close of everything."*

This sentiment echoes my own conviction that optimizing mitochondrial health is the single most important step you can take to achieve vibrant, lasting health.

Diving Into Your Mitochondrial Landscape

Patel provided fascinating insights into the sheer scale and complexity of the mitochondrial network within the human body. There are about 100,000 trillion mitochondria in your body,[2] each with hundreds of electron transport chains.

The staggering number of these energy-producing organelles, each with their own intricate machinery, underscores just how vital they are to your cellular function and, by extension, your overall wellbeing. One of the most intriguing aspects of our discussion centered on the endosymbiotic theory of mitochondrial evolution.

As Patel described, these organelles are believed to have originated as independent microbes that were incorporated into the earliest eukaryotic cells about 1.5 billion years ago. This symbiotic relationship not only allowed for the development of more efficient energy production, but also gave mitochondria the ability to "regulate key processes that tie to cell death and survival." According to Patel:[3]

> *"These organisms, and maybe they were aliens at the time, got incorporated into the cells, and they created the symbiosis that then allowed some magical next steps to happen. And everything in life is fixated on growth, and everything that's fixated on growth is dependent on energy. Whether it's a good or bad growth, it requires energy to do it, and so mitochondria changed that currency in a dynamic way.*

Biochemical processes that made energy before that were inefficient, right? You can cook things, but you couldn't cook them fast enough and sort of accelerate enough. Mitochondria gave us that acceleration to get to that next step. And from that perspective, people have sort of always thought of them as energy makers, the powerhouse of the cell. I think that's almost completely true.

But the other thing that they don't realize is, because we have this organism that's now a symbiont in our cells, it regulates other things as well. It needs to survive, and in order to ensure survival, it regulates key processes that tie to cell death and survival. I think that's the more important feature. Energy is a balance of that, but it's really their ability to signal, sense and organize …"

The Relationship Between Your Mitochondria and Cellular Membrane

Patel's groundbreaking work expands on the intimate connection between mitochondria and the cellular membrane, especially the specialized microdomains known as caveolae. He believes the cell membrane is actually the most important part of your cells:[4]

"I'll ask people what's the most important part of the cell? And most people will say the nucleus, because we're taught to think about the central brain and the control center of stuff. The next thing that people say is mitochondria, because they know about the energy and energetic systems. Very few people say the cell membrane is the most important part of the cell. And as a cell membrane biologist, this is the most important part, right?

It's what defines a cell. It's what defines who you are. When you have this conglomeration of cells come together, it's the first barrier that's going to see any kind of stress. I agree that in all these chronic diseases, mitochondrial dysfunction is the end effect. The primary effect, I would argue, is a defect in the membrane, which then ultimately leads to this demise of energy generation and utilization in the cell."

Further, as he explained, "Every metabolic cell has this interesting connection between the membrane and the mitochondria. And in the heart, there's this particular interaction where it happens almost all the time. If there's mitochondria at the cell surface, it's almost 100% of the time associated with this microdomain."

Even more intriguing, Patel suggests that these caveolae structures may actually function as a "capacitor for oxygen," serving as a specialized storage and delivery system for this vital molecule. He described how the high concentration of cholesterol within these microdomains allows them to bind and regulate the flow of oxygen into the cell, thereby protecting the mitochondria from the deleterious effects of oxidative stress.

"We think that this membrane actually becomes the storage conduit and the channel by which oxygen gets tempered and delivered into the cell," he explained. "It works as a capacitor, and we've published a bunch of reviews on this concept, and this idea that the caveolae is a capacitor for oxygen and metabolism."[5]

Your Mitochondrial-Gut Axis and Predicting Disease with Your Microbiome

Patel's research also highlights the intricate relationship between mitochondrial function and your gut microbiome. As he shared:[6]

> *"The gut and the rest of the mitochondrial network in your system are interacting and engaged, where, if your vagal nerve and your gut are connected, you're sending different signals in terms of who and what you are. It's changing the entire composition of that and you're making new metabolites that then we can capture in plasma that do unique, amazing things when we test this out in the cell-based system."*

This two-way communication between your gut and your mitochondria, facilitated by the production of microbial metabolites, represents a promising frontier in our understanding of how to optimize human health. As Patel noted, his research has shown

that even a short-term shift in the gut microbiome, such as that observed during a week-long meditation retreat, can have a profound impact on markers of metabolism and overall wellbeing.

Patel and colleagues have even used machine-learning algorithms to analyze gut microbiome data and predict the presence of various disease states. As he explained:[7]

> *"We can predict with just looking at the metagenomic sequence … you can train the machine-learning system what anxiety looks like in terms of the microbiome, and then give it some controls to say this is not what anxiety looks like, and then start feeding it knowns and having it predict.*
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> *It can predict anxiety at about 74% accuracy, cancers, because it's so populated with breast cancer, almost 90%. PTSD [post-traumatic stress disorder], which is a little more complicated, like 65%."*

Ultimately, Patel said, "With more and more data, you can get to the state where you'll be able to look at unique series of factors that are very limited. You want to run all of them to then start predicting various diseases." Then, you can dial in on the underlying causes and make changes to help prevent them.

The Black Hole Spiral of Premature Death

Your colon also plays a role in driving mitochondrial dysfunction and poor health. As I explained, I believe that the gradual breakdown of your colonic epithelium, driven by factors like overconsumption of **linoleic acid** (LA) from **polyunsaturated fats** (PUFAs) found in seed oils. This and other mitochondrial poisons lead to a disruption in the delicate oxygen balance within your gut.

This, in turn, creates an environment that supports the proliferation of harmful, oxygen-tolerant microbes, while inhibiting the growth of the beneficial, oxygen-intolerant microbes that are crucial for gut health and overall wellbeing. Mucin serves as the glue that holds your colonic epithelium together. The colonocytes, or cells lining your colon, create a barrier and seal that must be maintained.

When disrupted, I view this as a metaphorical "black hole spiral" — a progressive, downward spiral toward premature death.

Until an intervention addresses what is damaging your colonocytes and restores the proper oxygen levels, the population of beneficial, oxygen-intolerant microbes cannot be reestablished. This mitochondrial-gut microbiome communication is crucial, but if the oxygen-tolerant pathogenic bacteria predominate, the beneficial bacteria are crowded out and you simply are unable to produce the necessary metabolites to thrive.

Unless you can remove the excess oxygen from your colon, even the best lifestyle factors like exercise, sleep, nutrition and supplements will not lead to improvement. However, you cannot simply introduce probiotics to replenish your oxygen-intolerant microbes, as commercially available probiotics are often non-viable.

They provide postbiotic benefits but cannot serve as a true "seed" to reestablish the proper microbial community. The environment must be right for these microbes to thrive, just as you cannot expect a seed to grow in a desert. Avoiding mitochondrial poisons, like LA and **endocrine-disrupting chemicals**, is key toward this end.

Overcoming the Limitations of Conventional Mitochondrial Testing

Patel also shared insights on the limitations of conventional approaches to assessing mitochondrial function. He explained that the majority of preclinical studies utilize young, healthy animal models, which fail to accurately reflect the complexities of human disease.

To overcome these challenges, Patel highlighted the importance of developing more sophisticated, clinically relevant models that incorporate factors like age and existing disease states. "If you're going to develop preclinical therapeutics, you really have to look at disease models that you're testing it in, ultimately, and relevant disease models that model the human condition."[8]

Patel also shared his perspective on the limitations of traditional muscle biopsy-based mitochondrial testing, which he described as "painful" and "self-limited." To address this, his team has been exploring the use of novel, less-invasive approaches, such as the analysis of blood samples:[9]

> *"We've been doing this in cell systems for probably about a decade. And who knew humans would be interested in knowing about their mitochondrial biology? And so we were working on a series of studies where we were doing muscle biopsies, which is the gold standard. We do lots of clinical trials with collaborators on campus.*
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> *They give us muscle tissue, we then look at mitochondrial function in that muscle tissue and give you all kinds of ideas about whether, using fat, glucose, ketones, how which complex is defective? How you're using electrons, is it working the right way? Those sorts of things that you can manipulate at that level. The problem is there's no way to scale this, and it's painful."*

Instead, Patel and his team developed a commercial test called "**mescreen**" that allows individuals to obtain a comprehensive assessment of their mitochondrial function from a simple blood draw. This innovative approach not only provides valuable insights into a person's metabolic health, but also paves the way for more widespread adoption of mitochondrial testing as a tool for preventive and personalized health care.

Forging a Collaborative Path Forward

The intersection of mitochondrial biology, gut health and personalized medicine represents a promising area for future collaboration. With Patel's expertise in mitochondrial biology and the gut-microbiome axis, and my own focus on the crucial role of the colonic environment, I believe we are poised to make significant strides in our understanding of how to optimize human health and longevity.

As we move forward, I am excited to continue exploring the miraculous world of mitochondria, and to uncover the intricate connections between these cellular

powerhouses, the gut microbiome and the overall state of your health. I believe we can uncover the keys to unlocking vibrant, lasting wellness for individuals and communities alike.

Looking ahead, the work of researchers like Patel holds immense promise for the future of health care. By deepening our understanding of mitochondrial function and its intricate relationship with the gut microbiome, we can develop more targeted, personalized interventions to address the root causes of chronic disease.

From the use of machine learning to predict disease risk based on microbiome profiles, to the exploration of novel mitochondrial-targeted therapies, the field of mitochondrial medicine is poised to revolutionize the way we approach wellness and longevity.

By empowering individuals with the knowledge and tools to **optimize their mitochondrial health**, we can unlock a new era of proactive, preventive health care that addresses the underlying drivers of disease, rather than simply treating the symptoms.

Sources and References

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