

## **The Mitochondrial Theory of Cancer and the Ketogenic Diet A Book Review and Overview of Tripping Over the Truth**

### **Background:**

Today, cancer receives more funding from the NIH than any other disease that affects humans. The main premise of Christofferson's book is that cancer may not actually completely be a genetic disease and that it is a disease of defective metabolism. This idea didn't start with him, however. It began with Otto Warburg in 1924. Since then Warburg's theory has lost popularity among those in the scientific community, largely because of narrow thinking and discouragement of risk-taking, Christofferson claims. Warburg's theory rests in mitochondria, the power plants of the cell.

Every cell in the human body contains these mitochondria. Mitochondria have important functions in the human body in cellular energy metabolism, free radical generation and apoptosis (killing of damaged cells). Defects in mitochondria have been thought to play a role in the development and progression of cancer since the development of the Warburg hypothesis.

Warburg was the first to notice that tumor cell slices consume glucose at a higher rate than normal tissue slices at normal levels of oxygen. Warburg hypothesized that tumors are generated when the mitochondria within cells do not adequately respire and exhibit glucose fermentation to lactate. There have been several mechanisms proposed: the upregulation of rate-limiting steps of glycolysis, the build-up of mutations in the mitochondrial genome, the hypoxia-induced (low oxygen) switch from mitochondrial respiration to glycolysis (burning glucose) and continued use of oxygen or the metabolic reprogramming resulting from the loss-of-function of enzymes like fumarate and succinate dehydrogenases or gain in function of tumor causing genes. Alternatively, the suppression of the built-in apoptotic mechanisms can directly lead to the types of cells that Warburg described. The fact that some of these suppressors are part of the mitochondria's normal processes may indicate that mitochondria have a big role in the development of cancer. To be brief, Christofferson claims that damage to mitochondria happens first, then genomic instability, and then mutations to DNA. Conventional scientists like physicians fixate on mutations to DNA which Christofferson believes are only the side effects of mitochondrial damage.

### **Effects of the ketogenic diet on cancer cells:**

Dr. Thomas Seyfried was one of the first to notice that caloric restriction shrank tumors. In theory, caloric restriction drives down blood glucose and forces cancer cells to compete with healthy cells for they need to survive. Seyfried thought he could do better, however, by keeping calories restricted but virtually eliminating carbohydrates in favor of consuming fat and protein. This diet was first discovered to reduce seizures in patients with epilepsy. When this diet is started, the liver starts making ketone bodies that float around in the blood. Even though the brain is dependent on glucose (the same fuel that Warburg hypothesized that some cancers need to survive) the brain can also survive on ketone bodies. While healthy cells in the heart, brain and muscle can make the transition burning ketones, cancer fortunately cannot. This metabolic pressure placed on the cancer cells can often work well with conventional cancer therapies. There is current evidence that a Ketogenic Diet (KD) might improve quality of life and blood parameters in some patients with advanced metastatic cancers. In order to completely assess the diet's effect on quality of life or cancer progression, more randomized studies with sufficient numbers of patients are needed. Any patient that wants to try the Restricted Ketogenic Diet (R-KD) should only do so under the supervision of a healthcare provider.

### The Restricted Ketogenic Diet Defined:

Christofferson says the first step is to determine if the patient is a good candidate for a fast. After that, the ideal way to start the diet is with a water only fast for 48-72 hours to quickly enter ketosis. Some patients may choose to simply enter the maintenance phase of the diet. The diet itself is not complicated. A patient would begin by reducing their carbohydrate intake to less than 12 grams per day. The patient should be advised to consume 0.8 to 1.2 grams/kg of bodyweight per day of protein. The rest of the patient's diet will consist of fats like olive oil, coconut oil, and butter from grass-fed cows. There should be 4 grams of fat to every gram of protein. The entire point of the diet is to reverse the ratio of glucose to ketone bodies. Christofferson says the ideal blood glucose should be around 70-80mg/dL and that ketones should be around 2-4 mM according to what Seyfried described as the therapeutic zone. These levels should be checked 3 times a day. What's best for the patient, however, should be determined by patient in conjunction with a medical provider. It's important to note that the essence of the ketogenic diet is to restrict calories overall.

### Suggested foods for the ketogenic diet

Vegetables	Fruits	Proteins (free range, grass fed, organic)	Dairy	Fats and Oils
Asparagus	Apples (few thin slices)	Beef	Butter	Animal fat and Lard
Broccoli	Berries	Lamb	Cheese (cheddar, parmesan, Brie)	Butter or ghee
Cabbage	Grapefruit	Pork		Coconut oil
Cauliflower		Poultry		Omega-3 fish oils
Celery		Wild Game Meats		Salad dressings/Mayo
Kale		Eggs (high in omega- 3s)		
Mushrooms				
Spinach				
Zucchini				

### References

<http://molecular-cancer.biomedcentral.com/articles/10.1186/1476-4598-1-9>

<http://www.ncbi.nlm.nih.gov/pubmed/22399428>

<http://www.nature.com/onc/journal/v25/n34/full/1209589a.html>

<http://journal.frontiersin.org/article/10.3389/fonc.2013.00292/full>

[http://www.medscape.com/viewarticle/757713\\_6](http://www.medscape.com/viewarticle/757713_6)

Robert E. ListECKI, Pharmacist, Glen Ellyn Pharmacy. Prepared by Tolu Oladini, PharmD Candidate 2016 Midwestern University.