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How Refined Sugar Fuels Cancer

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Theme: Science and Medicine

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All dietary carbohydrates are digested into sugars called glucose. Glucose, in turn, can be metabolized (burned) for fuel using two different pathways. First, the glucose is metabolized into pyruvate. The pyruvate can then either enter the glycolysis pathway in the cytoplasm of the cell and produce lactate (this is an inefficient backup pathway), or it can be converted into acetyl-CoA and shuttled to the mitochondrial electron transport chain, which results in optimal energy production

The Warburg Effect refers to the observation that if your body has access to enough oxygen, it will preferentially burn (oxidize) glucose in your mitochondria by converting the pyruvate into acetyl-CoA

The state of mitochondrial physiology that Warburg accurately identified occurs when your body has enough oxygen and the mitochondria are not maxed out, yet still uses the backup glycolysis pathway. This is also called cancer metabolism. It gives the false impression that cancer is using glucose to supply its metabolic needs for energy, but it is merely an illusion

The primary reason glucose cannot be burned in your mitochondria is because the mitochondria are dysfunctional. This dysfunction is the result of the electron transport chain (ETC) being backed up with an excess of electrons that are unable to flow easily through the five complexes. This condition is known as reductive stress. In this situation, your body has no choice but to use the backup system, glycolysis

Contrary to natural fructose (found in ripe fruits and honey, for example), refined sugars and many starches are more likely to cause gut dysbiosis that leads to the production of endotoxin. This endotoxin is one of the factors that destroys mitochondrial function, resulting in cancer metabolism (the Warburg Effect) where glucose is burned through glycolysis

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There's a common misconception that all sugar, i.e., carbohydrates in general, will act as fuel for cancer, but nothing could be further from reality. When it comes to the "sugar fuels cancer" issue, it's important to make a distinction between the sources of the carbs.

While it is technically accurate to call all carbs sugar, there is a radical difference in the source of the carbs — ripe whole fruits versus starches, for example, and whole fruits versus refined processed sugar (ex: table sugar and high fructose corn syrup).

Many studies have indeed found a strong and accurate link between refined sugar intake and cancer risk. For example, research[1] published in 2014 found that Stage 3 colon cancer patients who drank two or more servings of sugar-sweetened beverages per day had a 67% higher risk of cancer recurrence and death compared to those who consumed less than two servings per month.

The key term here is "sugar-sweetened beverages." There are significant differences between liquid refined/processed sugar and unrefined sugars from fruits.

Refined sugars, as well as many starches, are a common cause of endotoxin production in your gut, which destroys mitochondrial function and results in cancer metabolism, whereas the fructose present in whole foods does not typically result in the production of endotoxin. This is one of the primary differences between refined sugar and fructose from ripe fruit and helps explain why refined sugars fuel cancer.

The Many Downstream Hazards of Glycolysis

The glycolysis pathway is great when you need quick fuel when you are activating your Type 2 muscle fibers. But if this is the primary way you burn glucose, then you are in a catastrophic metabolic state because you're promoting insulin resistance and diabetes and creating loads of lactate as a waste product instead of healthy CO_2 and metabolic water.

Lactate increases reductive stress, which causes reverse electron flow in the mitochondria and increases the ROS to 3% to 4%, which is 30 to 40 times more than when glucose is burned in the mitochondria. What's more, glycolysis generates only two ATP for every molecule of glucose, which is 95% less energy than would be generated if the glucose were metabolized in your mitochondria.

You're also promoting cancer, because cancer cells preferentially use glycolysis. But again, it's not sugar that is driving the cancer process per se. It's really rooted in mitochondrial dysfunction, and fatty acid oxidation (metabolism of fats instead of glucose) is part of what causes that dysfunction.

For a long time, I believed fats burned "cleaner" than carbs — that's one of the "selling points" for keto — but I've since realized we had it backward. Glucose, when burned in the mitochondria, actually burns far cleaner than fat.

So, it's important to get your macronutrient ratios right, because if the glucose you eat is constantly shuttled into glycolysis, you're fueling cancer. At the same time, the fat you consume ends up in fat storage rather than being used up for fuel.

Ultimately, you want to burn glucose in your mitochondria. One exception is when you're doing high-intensity exercise. When you're engaging your Type 2 fibers, it's safe to use the

glycolysis pathway, but that's the exception. When you're resting, you want to burn glucose in your mitochondria.

The only way to ensure that is to keep your dietary fat content below 35% of your total calories. If you're insulin resistant, which means you're metabolically inflexible, that threshold may be closer to 20% or even 10%. So, if you're insulin resistant, you'll want to significantly lower your fat intake until your insulin resistance is resolved. Then you can increase it to 30%. All of this is easily calculated by using a free online program called Cronometer.

The Warburg Effect

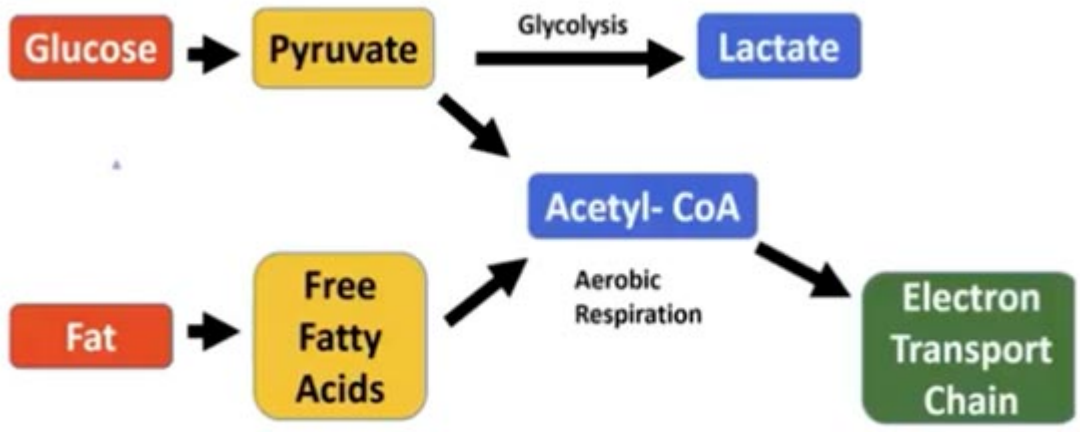
You've probably heard that the Warburg Effect is involved in cancer. The Warburg Effect refers to the observation that cancer cells produce lactate even in the presence of adequate oxygen (aerobic respiration). Lactate is a byproduct of glycolysis (nonaerobic respiration).

I realize the above explanation of the Warburg Effect is technical, but the key point here, and what Warburg identified, is that if your body has access to enough oxygen, it will preferentially burn (oxidize) glucose in your mitochondria by converting the pyruvate into acetyl-CoA.

If you find this concept confusing, please be kind to yourself. Even some highly knowledgeable physicians in natural medicine misconstrue this point and incorrectly assert that Warburg demonstrated cancer is fueled by sugar. I, too, held this belief before delving into biologist and bioenergetic medicine pioneer Ray Peat's work. However, it's evident that such a claim is a profoundly serious misinterpretation of Warburg's research.

Glucose Metabolism 101

All dietary carbohydrates are digested into sugars called glucose. Glucose, in turn, can be metabolized (burned) for fuel using two different pathways, as illustrated below.



First, the glucose is metabolized into pyruvate. The pyruvate can then either enter the glycolysis pathway in the cytoplasm of the cell and produce lactate, or it can be converted into acetyl-CoA and shuttled to the mitochondrial electron transport chain.

There are many factors involved in cancer formation. It's most assuredly not as simple as "cancer thrives on sugar." Cancer cells can survive and thrive on protein and fats as well.

Cancer cells simply use the glycolysis pathway — the same pathway glucose goes through when your glucose metabolism is impaired in the mitochondria.

This is the same pathway that your body uses when it reaches its limit to produce ATP in the mitochondria, which is the most efficient and least damaging way to produce energy. The downside is that this pathway is fine for normal activities, but when you engage in activities that exceed your mitochondria's energy-producing capacity, like high intensity exercises, then glycolysis is the healthy and normal way your body produces energy.

Oxygen, Glucose and Cancer Metabolism Explained

In the case of vigorous exercise, your mitochondria are not really impaired, but merely maxed out, as they have reached their threshold to produce ATP when oxygen is present. They simply are unable to supply your body's demand for energy. It is like driving a car with the gas pedal pushed to the floor and it simply is unable to go any faster, so the backup pathway must be activated.

The backup system is glycolysis, which creates energy very quickly but is highly inefficient and wastes loads of resources, does not produce CO_2, and creates reductive stress by generating lactate. In this situation, this is not a problem, as it is a backup and you're not going to be sprinting for very long and can easily recover from this relatively short-term abuse, which has many hermetic health benefits.

The state of mitochondrial physiology that Warburg accurately identified occurs when your body has enough oxygen and the mitochondria are not maxed out, yet still uses the backup glycolysis pathway. This, my friends, is also called cancer metabolism.

It gives the false impression that cancer is using glucose to supply its metabolic needs for energy, but it is merely an optical illusion. Even brilliant research scientists like Dr. Tom Seyfried, a leading expert on the theory of cancer as a metabolic disease, are confused about this. I would love to interview Tom about this, but he and most are so conformationally biased, they refuse to reconsider their position on this point.

What Causes Your Body to Switch to the Warburg Effect?

This is the crux of the problem that virtually no one in health understands. Why on earth would your body do such a foolish thing as to burn glucose in the inefficient and pathology-producing backup glycolysis pathway and not in your mitochondria? If you understand the answer to this question, you will know more about molecular biology than virtually every physician, including nearly all functional medicine doctors.

The primary reason it fails to burn glucose in your mitochondria is that the mitochondria are seriously damaged and have what is termed mitochondrial dysfunction. This is the result of the electron transport chain (ETC) being backed up with an excess of electrons that are unable to flow easily through the five complexes. This is a condition known as reductive stress, which refers to an excess of negative charges due to the electrons.

Your body has no choice but to use the backup system, glycolysis, when the mitochondria have maxed out their capacity to produce energy. If it fails to use the backup system, you will not create enough ATP and you will simply die because your body must have fuel to run its metabolism. It is the same thing that happens to a fire when it runs out of fuel.

This is the real Warburg Effect. Nearly everyone believes that cancer feeds on sugar, but that is simply inaccurate. The truth is the polar opposite. Cancer cells have such seriously damaged mitochondria they are simply incapable of burning sugar in the mitochondria and must rely on the backup system to survive.

This is why the most effective strategy is to not jump to low carb keto to avoid feeding the cancer, but rather to use metabolic therapies that fundamentally address why the cells are unable to oxidize sugar in the mitochondria.

Once you fix the mitochondria and allow the cancer cells to metabolize glucose in the mitochondria, the cancer regresses back to normal healthy cells because the mitochondria work again and they don't require to use the emergency backup system.

Refined sugars and many starches are more likely to cause gut dysbiosis that leads to the production of endotoxin. This endotoxin is one of the factors that destroys mitochondrial function, resulting in cancer metabolism (the Warburg Effect), where glucose is burned through glycolysis.

What Causes Mitochondrial Dysfunction?

There are many factors that contribute to this, but I can strongly assure you that a diet including a moderate amount of healthy ripe fruits is not one of them. The fruits are actually part of the cure for cancer. There are four primary contributors to mitochondrial dysfunction:

- Excess linoleic acid (LA)
- Estrogen dominance
- EMFs
- Endotoxin

These all play major roles, but excess LA and estrogen dominance are clearly the leading contributors resulting in the vast majority of cancers resulting from mitochondrial dysfunction. This is largely because LA and estrogen negatively impact your body in many similar ways. They both:

- Increase free radicals that cause oxidative stress and damage your mitochondria's ability to produce energy.
- Increase calcium intake inside the cell that causes an increase in nitric oxide and superoxide that increases peroxynitrite that also increases oxidative stress.
- Cause an increase in intracellular water causing your body to retain water.
- Slow down your metabolic rate and suppress your thyroid gland.

Nearly everyone in the developing world has 10 times the amount of LA in their tissues than their ancestors of 100 years ago had. This PUFA is very susceptible to oxidative damage and produces free radicals like reactive aldehydes in your body that destroy your mitochondria.

These toxic metabolites of LA create enormous amounts of reductive stress as a result of electrons building up in the ETC and blocking the forward movement of electrons to complex IV and V to create ATP.

And, because LA is embedded in the inner mitochondrial membrane, it gets damaged and leaks protons that normally build up in the inner mitochondrial space. This proton gradient is

responsible for driving the nano motor in complex V to create ATP. Both processes combine to shut down and ultimately prematurely destroy the mitochondria.

Finally, when you eat carbs like starches, they can end up feeding bacteria in the intestine, which creates endotoxin that is a potent mitochondrial poison.

Refined Sugars Versus Sugar From Whole Foods

Now, when it comes to sugar feeding cancer, this really only applies to refined sugars, as well as many starches, because they are a common cause of endotoxin production in your gut.

As mentioned, endotoxin destroys mitochondrial function and results in cancer metabolism, whereas natural fructose does not typically result in the production of endotoxin. This is one of the primary differences between refined sugar and fructose from ripe fruit and helps explain why refined sugars fuel cancer while natural sugars don't.

If you have healthy mitochondria (which most people do NOT have) then refined and sugar from whole foods like ripe fruit would be burned in the mitochondria. The problem is, over time, the starch or refined sugar will increase endotoxin, which will prevent the mitochondria from burning any glucose well, whether from fruit or high fructose corn syrup.

The other point to consider is that there is a wide variability in the human microbiome. Many people have seriously compromised microflora with an excessive preponderance of gram-negative bacteria that contain the lipopolysaccharide (LPS) in their cell membrane that converts to endotoxin once these bacteria die, and their cell membranes are metabolized. This radically increases a person's ability to have an adverse reaction from undigested starches.

One of the ways a person can improve this scenario is to implement a microbiological principle known as competitive inhibition which involves supplementing with a probiotic like lactobacillus, or fermented foods, that are predominantly gram-positive bacteria and do not contains LPS in their membranes. This will crowd out or displace the gram-negatives over time, and increase an individual's tolerance to these undigested starches as they aren't fertilizing the growth of the LPS containing bacteria.

The Best Fuel for Mitochondria and the Role of Carbs in Your Body

In the end, the fundamental health truth is that glucose is the ideal fuel for your mitochondria and the one that will create the most energy with the least amount of "exhaust" in the form of free radicals causing oxidative stress that damages your mitochondria, cell membranes and proteins. It will also create the most carbon dioxide in your body which is highly beneficial for your health.

Many mistakenly believe, like I previously did, that fat is the ideal fuel in your mitochondria, but that would be a serious mistake. Fat is an important and crucial fuel that many cells, like your heart, rely on, but it never was designed to be your primary fuel. It is merely a backup fuel to keep you alive long enough until you can find some healthy carbs.

Carbs are so important that if you don't eat any, your body will make between 150 to 250 grams a day because your brain requires sugar. Without sugar you will go into a hypoglycemic coma and die. So, to keep yourself alive if you aren't consuming carbs, your

body will release stress hormones like glucagon, adrenaline and cortisol that will shred the protein from your muscles and bones to send to your liver to make glucose.

Solutions

This is really a mind-bending new way of viewing carbs, and it took me nearly a year to wrap my head around it. I have posted a podcast with Dr. Jay Feldman at the top of this page that I believe you will help you understand it better. More than likely, you will need to listen to it a few times. I listened to it five or six times and may review it a few more times, it's so good. In closing then, the solutions, if you want to lower your risk of cancer, would be to:

- Lower your LA intake as low as possible by avoiding processed foods, seed oils, chicken, pork, seeds and nuts
- Making sure you're eating healthy carbs such as ripe fruit
- Supplement with a good probiotic or fermented foods to crowd out gram negative bacteria in your gut
- Avoid most grains, primarily because they are high in LA but may also contain undigestible starch
- Optimizing your mitochondrial function in general
- Decreasing lactate production and increasing carbon dioxide, as they have opposing effects.[2]You can learn more about this in "The Biology of Carbon Dioxide"

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Notes

[1] PLOS ONE 2014; 9(6): e99816

[2] RayPeat.com Mitochondria and Mortality

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