

The Sugar Hill, Part 1

Research into the nature and dangers of chronic calorie-dense carbohydrate consumption

Transcript of: The Sugar Hill, Part 1

Description: Steve describes his four-month focus upon dietary carbohydrate and explains the experience and biochemistry associated with his surprising switch into the state of "nutritional ketosis" which occurs whenever humans consume a non-carbohydrate-based diet.

High quality (64 kbps) mp3 audio file URL: <http://media.grc.com/TheSugarHill-pt1-64kbps.mp3>

Quarter size (16 kbps) mp3 audio file URL: <http://media.grc.com/TheSugarHill-pt1-16kbps.mp3>

Leo Laporte: This is TWiT Live Special #124, recorded May 6th, 2012: The Sugar Hill.

Hi, Leo Laporte here, and this is something kind of unusual. Our good buddy Steve Gibson is also here with us. Steve, of course, is the host of Security Now!, a security guru, a computer - I want to say this upfront - computer scientist by training. But Steve, like many of us geeks, has a real interest in hacking the body, as much as hacking technology, particularly to help us with our health and longevity. And he's been, I know, for the last year or so really been paying a lot of attention to health and nutrition. And you did a special on Vitamin - first of all, welcome. Steve Gibson, good to talk to you.

Steve Gibson: Hi, Leo. Great to be with you.

Leo: You did a special on Vitamin D last year that people were very, very interested in. And we thought we'd take, and not do this in Security Now! because I think that really Security Now! is dedicated to security, but to take an hour of our broadcast day and devote it to this topic so that people who are interested can learn more.

So, first of all, I thank you for doing this and kind of putting yourself on the line. There are a lot of people in the nutrition field and the medical field who want a monopoly on all this, and I don't know if that's, strictly speaking, fair. I think there's a lot of information out there, and sometimes conventional wisdom is far from wise. So I'm very interested in what you've found. And you use yourself as a guinea pig, I gather.

Steve: Well, yeah. So the impetus for this is that, since you and I last spoke about this topic, something amazing, a series of amazing things have happened to me. And completely unexpected and really interesting. And I've spent the last two and a half weeks drilling down to understand what has been going on and to understand the short and long-term consequences, the biochemistry of this event and series of events. So I'm not sure how much we'll get into this hour. You've said, if we don't get enough done, we might be able to continue this next week.

So first, the way I want to organize this is to tell you what happened, and then tell you everything that I know about the consequences, I mean, like why this happened and what it means. So we'll sort of just take it from there. And I know this is going to be something that you and anybody who's really interested in the dynamics of how our body and our diets affect our lives will care about.

Leo: Good. I'm excited. I'm fascinated. I've got my notepad and pen ready. I do want to give the disclaimer that you're not a physician. You're not a nutritionist. This is not your business. You're just a smart guy who's done a lot of research on his own. And of course nobody should take our advice without consulting their own medical authorities first.

Steve: Right.

Leo: That's just so I don't get sued.

Steve: Right.

Leo: Now, go ahead.

Steve: Okay. So as you know, starting around the beginning of this year, 2012, I became interested in this whole issue of paleo diet stuff, the notion that - Gary Taubes was part of the genesis of this, as were others. There's a Ron Rosedale who's involved, and a Jeff Wolfe, or rather Robb Wolf and...

Leo: It's a huge, it's a huge trend right now.

Steve: Well, and I had no...

Leo: And by the way, fad diets, many of them are crap.

Steve: I was going to say, I have no interest in fad diets at all. And I heard you before we began recording mention that what you're doing currently is not a diet. And so...

Leo: Diet is a bad word because it implies it is a temporary change in eating to lose weight so that you can then go back to doing what you were doing before. And we're not, I'm not talking about that. I mean what I eat, my dietary - but it's forever, I hope. I want to find the right way to eat.

Steve: There are two meanings to the word. One is sort of the popular, oh, I'm dieting because I want to lose weight. And if someone then stops doing what they were doing differently and returns to what they had been doing, their body will take them right back to where they were.

Leo: As I have learned over and over again.

Steve: Okay. So because I was curious, and also because I fundamentally believe that we evolved for two million years during this long Paleolithic era in an environment without access to agriculture. And it's only agriculture that gives us the product of contemporary grain - wheat, rice, even potato starches - in the kinds of quantities that we have. The question is, are our bodies adapted to this type of food, this essentially manmade food that wasn't what hunter and gatherers had access to for several million years, where a chunk of their day was spent working to feed themselves and their small communities.

So because I was interested - and, I mean, I'm looking, actually I've learned that I'm much more of a skeptic than I thought because I've been very surprised by a number of things that have happened in the last 20 days, which I didn't expect. What I did was I began for a couple months just cutting out all carbohydrates. What I wanted to see was whether I could measure an increase in my body's sensitivity to insulin and also play with other common factors like triglycerides, which, I mean, the argument is that, even though they are blood fat, that they're not from dietary fat, they're from dietary carbohydrate. And so I made some changes to my diet to play with these numbers and saw immediate results. But I also expected that changes in things like sensitivity to hormones, like insulin, I wouldn't see for months and months. So I was completely prepared, and am, to avoid all of these products, all wheat products - cookies, crackers, cakes, pretzels, chips, all of that, potatoes, rice - and I love Chinese food. But unfortunately rice is carbohydrate. We'll be talking a lot about the biology of this later.

But I want to explain what happened, which was on Tuesday, of April 17th, I hadn't been monitoring my heart rate for a long time on my stair climber. I've been using the stair climber as my preferred mode of exercise for decades now, and I've talked about it from time to time on the podcast. And I am very well trained up on the stair climber. I can go 35, 45 minutes, sometimes I'll push myself to do 60 at a very good pace. And so because this is something I do almost every day, cardiovascularly, although I'm a deskbound computer guy, I'm very well trained cardiovascularly, so that I can go out and do, like, a 25-mile bike ride up steep hills just whenever I want to. But the batteries had run out of my heart monitor and monitor wristwatch and things, and I hadn't watched myself for one of my workouts for a long time.

So this Tuesday, which was actually the Tuesday before the last podcast you and I did before you left for Norway, that Tuesday afternoon I strapped on my heart monitor and started the wristwatch recording, got on the stair climber as I always do, and set off on - because I was recording, I wanted to do an extra long one, which for me is 60 minutes. And I need to explain that, I mean, this is hard for me to do. I mean, 60 minutes is like, oh, goodness. I notice that I normally am trying to read while on the stair climber so I don't die of boredom. And at about 35 to 40 minutes I'm really wanting to stop. And in fact I'm unable to really concentrate much on the reading because I'm just working to get through this exercise.

And what I always know, and I did see this time, is by around the end, maybe around 45 minutes or so, or maybe 50, my heart rate is up at about 153 beats per minute. And that's where it ends. It's like, it gets up, climbs steadily over the course of the workout, up to about 153. And I am at that point utterly exhausted. I stop, I rest on the bars of the stair climber and catch my breath. Then, after I've cooled off and stopped perspiring, and I shower, I'm a little shaky. I mean, I've just - I've worked so hard during that period of time that I'm used to being a little, not really fragile, but I've got to make sure when I'm washing my feet I don't slip in the shower because, I mean, I'm not all there yet. And then, about an - I notice it maybe 45 minutes later, is this wonderful endorphin

high. And I've often wondered if maybe one of the reasons I work out the way I do is I really like those endorphins. I mean, it's just a fantastic feeling.

So that was what happened Tuesday. And, I mean, I monitored this. I got a nice recording of my heart rate. I was very pleased with my heart rate recovery when I stopped. My heart rate just drops right back down to about 100 and then slowly recovers, continues to drop. But, I mean, as we know, heart rate recovery is one of the measures of good cardiovascular fitness.

So went through the rest of the day. Got up the following Wednesday the 18th. And when I peed, I noticed this odd smell from my urine. And I thought, wow, that's weird. And I'm sensitive to asparagus, and many people may have noticed that, if they like asparagus and eat it, that it does change the smell of your urine as a consequence of just some of the chemistry in asparagus interacting with your body. Apparently not everyone has that happen, but I do. And so - but I hadn't had any asparagus. But it was that kind of a scent. I mean, there was definitely something different that was strong. And I thought, well, that's interesting, but didn't think too much of it. You and I did the podcast that late morning, and I went about the day.

Oh, and also I should say, when I continued to urinate, to pee, as I did throughout the day, always with this interesting odor that I had never experienced before. And the same thing Thursday morning. And after breakfast I thought, okay. I've got to get down to what's going on here. What's the story? And in the back of my mind, just from things I had read, and I don't even remember where I had encountered it, but I Googled "ketosis urine smell." And sure enough, lots of people know about this.

Ketosis is - and I'll talk a lot about it. For the moment I'm really tuned up on what this is all about. It's a process of energetics that our liver is put into when we are burning fat. And there's a lot I want to say about it, but I want to continue to explain what went on. So people who are on low-carbohydrate diets, where they hold their total dietary daily carbohydrate to below about 50 grams a day - carbohydrate of all kinds has 4 calories per gram, so 50 grams would be 200 calories worth of carbs. When that's done for some length of time, their body will switch, their liver predominantly will switch into this mode where it's producing what's called "ketones," which are - and I'll explain, again, the biology of this at length in the future. But they're chopped up fatty acids which are sort of a surrogate for glucose. All of our muscles and cells in our body are able to burn three different energy substrates: glucose, which comes from carbohydrate typically, also from protein. You can have something called gluconeogenesis to synthesize glucose from protein, or fat can also be burned, and ketones.

So I started reading about this. And in looking around I learned that there are some ketosis sensor sticks, a little home urine test you can do because there is a variant of ketosis which is a bad thing to be in, which is called "ketoacidosis." And in fact ketosis has a bit of a bad reputation just due to historical inertia because it was first observed in diabetics who had uncontrolled diabetes. And in fact that's why Bayer produces these things called "Ketostix," is to help diabetics check themselves if they are worried that they may be producing ketones. It also happens that people who are doing low-carb dieting can use these in order to see if they're producing ketones, which low-carb dieters regard as a sign of success in getting their body to do this. And I'll explain why it's what you really want.

What is interesting is that, remember that all I did was to minimize my carbohydrate intake. So that essentially, that and the exercise was sort of the catalyst. And also I had been minimizing my carbohydrate intake for some length of time. So I ordered some Ketostix through Amazon, but they don't ship them themselves, so it was going to be till Tuesday. But I did notice that Walmart and CVS Pharmacy had them, and I have a CVS

nearby. So Friday I went to get some. And sure enough, I was showing a high level of ketone production by my liver.

People who have a lot more experience with this than I had at that point, although I've got quite a lot now, notice three things when they're in this state of ketosis. There are three primary types of ketones which are produced. They've got fancy long chemical names, mostly. There's one that's acetoacetate, and then beta-hydroxybutyrate, and then acetone. Well, the first two, the acetoacetate and the beta-hydroxybutyrate, are essentially the ones we want. The acetone is an unneeded byproduct of our liver's breaking long chain fatty acids down into smaller pieces. So it ends up, this acetone ends up being expelled in urine and breath, when we exhale it, and also perspiration.

So I have a friend at Starbucks who sometimes goes low-carb in this dietary cycling we were talking about. And she notices it in her breath. I saw a report on the 'Net from a mother whose kids wonder if she's chewing fruit gum when she's in a low-carb diet because that's the smell of her breath.

So it was Friday that - and I think it was about Friday, maybe it was Thursday - I began realizing my skin smelled. I mean, and it was - I would describe it as sort of a musky, fruity smell. My whole body. So it was coming out in my perspiration. And I was going to meet Jenny on Saturday down in Laguna Beach. And as we were corresponding through email, I said, "By the way, I smell." And she said, "What? What do you mean?" And I said, "Well, tell me what you think." Anyway, so the good news is she likes it. Caveman musk or something, I guess, I don't know. But so - ketogenic pheromones.

So this is Saturday, after four days of this. And I continued to read and learn about it. I noticed an apparent decline in the amount that I was smelling myself, both urine and skin. I never really noticed it in my own breath. It turns out that these ketones, when exhaled, can false-positive breathalyzers because the acetone turns into something called "isopropanol," which is very similar to ethanol, which is what the law enforcement breathalyzers are trying to sense. But their response curve isn't tight enough not to also pick up on the isopropanol. So that's been a problem for people.

There was an instance where someone, I think it might have been in Sweden somewhere, had a car with an intoxication interlock, and because he was on a low-carb diet, the car wouldn't start because it was mistaking the isopropanol in his breath for ethanol and said, uh, no, we're not going to let you drive. I've been unsuccessful in getting breathalyzers, little hand ones, to function, although there are some companies that have prototypes of breathalyzers specifically for sensing ketosis. There are also, in the same way that you can prick your finger to measure your blood glucose, there are some blood ketone measuring technologies which give you an accurate measurement. The reason that the Ketostix are not good for long term, and the reason I began to be less and less aware of it in my urine and perspiration, is that over time the dynamics of this change, and I'll explain all about that in a minute.

But the next thing I noticed was that Sunday evening after, like, so now we're about five days. I was out by myself and ordered a simple dinner, very conscious of avoiding carbs. So this was a shrimp cocktail, because I love horseradish in the cocktail sauce, and I was worried about the sugar in that. But it's like, well, okay, I'm not going to have much of it. And I'm avoiding all carbs. Many people say, well, you can technically allow yourself to get 200 calories worth. My feeling is, well, they're going to sneak in all over the place, so I'm not deliberately having any at all. And then I just ordered a nice piece of halibut and a large side of asparagus.

Well, I was halfway through the fish and the asparagus, and I was full. Now, I know myself very well, as any mature person does. And I don't get full with that little amount of food. I hadn't had anything since breakfast at all except sipping on coffee. And I was

full. Now, I mean, this was a huge change for me. And I thought, okay, maybe something else I had read about is true, because I had completely read a book by a Dr. Ron Rosedale, who is a medical doctor, understands the biochemistry in detail of this, and talked a lot about how low-carb diets change your appetite dramatically. And I'm thinking, uh-huh, okay, yeah, but wasn't expecting any of that. And yet something was very different. I mean, hugely different. So much so that I realized, okay, no more shrimp cocktail appetizer before my main course next time.

And then the next thing happened, which was I stopped being hungry. I mean, my hunger left. And, now, if I weighed 300 pounds, Leo, and you might be inclined to believe that I'm struggling to be less heavy, but losing that struggle, well, that would be one thing.

Leo: But wait a minute, Steve. You weigh 140 pounds. You're skinny.

Steve: Well, I weigh 155.

Leo: Oh, geez. I haven't weighed 155 since I was 10.

Steve: Well, get ready because this changes everything. I weigh 155 because I am fighting my weight and winning, rather than losing. I mean, it is by - I have no food in the house because otherwise...

Leo: Oh, that's interesting.

Steve: ...I would eat it.

Leo: Right. So you're saying you'd be heavy if you didn't pay attention to this stuff.

Steve: Oh, my goodness. I don't know what I would weigh.

Leo: Have you ever been fat?

Steve: I haven't, but my sister, who is of course genetically very similar to me, has been in a lifelong struggle and has never been the weight that she wants, despite trying for decades. So it is, again, the same sort of determination that has me on the stair climber for an hour has me - I've arranged my life so that I'm helping myself to be the weight I want to be, but by sheer force of will. I mean, really. And that's why, it may be hard for you to believe this, but, I mean, okay. So it is hugely significant to me that this lifelong problem is gone, virtually overnight. I am almost never hungry. Now, there's a whole bunch of, I mean, I'm at the beginning of an interesting chapter that I never expected. I read about it, several books' worth. It's like, yeah, okay. I just didn't believe it. But this is a radical change for me.

Now, your next book, Leo, is titled "The Art and Science of Low Carbohydrate Living."

Leo: I'm writing this down. We should mention, because we haven't, if you've been listening all along over the past year, you probably know the titles. But let me just give the titles that we started with. You mentioned Taubes earlier, and actually it was, I think, Paul Thurrott who first brought that to my attention.

Steve: Well, Gary Taubes's more popular book is titled "Why We Get Fat."

Leo: T-a-u-b-e-s. You can find these on Amazon, "Why We Get Fat" and his long-form "Good Calories, Bad Calories."

Steve: Correct.

Leo: That's where the conversation began. And then you've been reading a book which you recommended, which I love, called "Deadly Harvest," which Dr. Mom, we should mention, who is an actual physician, says is complete bunk.

Steve: Well, that's by Geoff Bond, G-e-o-f-f Bond.

Leo: B-o-n-d. And now this new book...

Steve: This new book is "The Art and Science of Low Carbohydrate Living."

Leo: All right.

Steve: It's by two doctors, both PhDs. One's an RD, a Registered Dietician. The other is an MD. And so I recommend it. It is an explanation of a lot of this stuff. It's written to a higher level, so much so that, as I was reading it yesterday, around in Chapter 10, I'm thinking, okay, wow. I mean, this is what I want, but I'll be a little more reluctant to recommend this to everybody because it is deep biological science.

The other one, though, that is more accessible, and now I believe it, and now I want to reread it because now I believe it, is - it's called "The Rosedale Diet." And this is by Dr. Ron Rosedale. And so that one I could suggest for somebody who's interested and looking at maybe weight loss and also performance. These guys - oh, and there is another book, by the way, "The Art and Science of Low Carbohydrate Performance," by the same two doctors, Phinney and Volek. And I finished it cover to cover, and it's very interesting because of what happened next, Leo.

So I go through a couple weeks. And, I mean, I'm amazed by something I can't believe, which is I'm 57, and I've been fighting against food since I was post-adolescent and struggling to keep myself at a weight I like. If this persists, and now I understand that it's real, and why, if this persists, then this changes my life. This changes, for me, everything. This is not something I will drop. I mean, I've had to give up carbs, which means no soda, no bread, no pasta, no cookies and crackers and so forth. And there is a radical change required because, if you're eliminating all of those calories that are traditionally received from carbohydrate, you need to replace them with something. And they are not replaced with protein because you don't want to overeat protein. They are replaced with fat. And that took me a while to get over because fat has been hugely

demonized in our society due to unfortunately some very bad science that was performed, which Gary Taubes does talk about extensively.

But I want to continue with what happened because it was this most recent Tuesday - so, let's see, so it was exactly two weeks from the Tuesday afternoon that I triggered myself into ketosis. Two weeks later, I thought, well, I mean, I've been enjoying this huge change, that I was no longer hungry. In fact, because I'm very busy, and I've got so much going on, I kept finding myself fantasizing about not bothering to eat, I mean, skipping because it was optional now. It was just, okay, well, but I have - there have been some changes.

I have not been losing weight, but I've been clearly losing fat and building muscle. My weight is still maintaining, although I do think it's dropping a little bit. There's day-to-day variation, so it's not easy to completely nail it down. But my pants are progressively looser on me. And I know that I've got good leg muscles from the stair climber. So there is some of that going on. I'm probably going to have to increase my caloric intake. But doing so will be a deliberate effort for me. I mean, I don't - I'm just not hungry anymore. And so I'm really interested, Leo, in the long term, if we can - if you're interested in pursuing this sort of path, to see whether you're able to duplicate this experience because it's dramatic for me.

But on the stair climber this most recent Tuesday, I strapped on my heart monitor again, and the wristwatch, started it recording, and began reading. In this case I was reading deeper into "The Art and Science of Low Carbohydrate Living" and just working along on the stair climber, enjoying the book, wasn't paying much attention. And at 34 minutes I thought, huh, I wonder what my heart rate is. The stair climber has an old version of the polar receiver. I'm using the newer coded versions, which it won't receive, so I can't see my heart rate on the stair climber's readout, but my watch receives it. So I look at the watch, and it says 153. Which I couldn't believe.

Leo: I hope that's not your heart rate.

Steve: Oh, yeah. Because I know what...

Leo: Oh, dear. That's pretty high, dude.

Steve: Well, I'm telling you, I really work out hard.

Leo: Okay, okay.

Steve: But my point was, two weeks before...

Leo: It was higher.

Steve: No. Two weeks before, at the end of 60 minutes, it was 153 from hell. I mean, it was at exhaustion...

Leo: Oh, I see. It was how you felt about it, right, right, right.

Steve: Yes. My subjective feeling of that heart rate is I cannot - I could barely force myself to continue. This time, at 34 minutes, it was that same rate, 153, and I didn't even notice it. I mean, and I was focusing on the book. I wasn't distracted by how hard this was. And, I mean, as a consequence of having all this instrumentation, I've established broad baselines for how I feel, when and where. And this is a change. This was phenomenal. And I also noticed that my breathing was relaxed and regular. I had said to some friends, my Starbucks friends, about a year and a half ago that one of the reasons I felt winded was maybe when I'm reading and I'm distracted, I'm not concentrating on breathing, so I need to focus on breathing because I need to do so much of it at the rate that I'm working out. And that's the way it was two weeks before.

This time, this last Tuesday, completely different. I was just sort of breathing in a relaxed, fine fashion, not winded, not gulping for air, not air-starved, as is one of the terms. And I also know why all of that has happened now, too. But I ended up finishing the hour without a great deal of trouble. I mean, it's still work. It was work I was doing. My heart rate ended up at 163, so 10 beats per minute higher now than it had been two weeks ago with the same amount of work being done on the stair climber. Yet an objective, I mean, a subjective radically different experience. I couldn't believe it. I stopped. I wasn't exhausted. I wasn't shaky when I was showering afterwards. And no endorphin reaction, which, frankly, I missed because I like that little bit of endorphin high. But that's because I had not stressed my body to the same degree that I had doing exactly the same amount of exercise two weeks before.

Now, essentially what this is all about is changing our body's energy metabolism from sugar to fat. And there are three reasons that I think someone might want to consider doing this. One is you get truly effortless weight management. And I mean that to the level where, until you experience it, if you're a person who has fought their weight through their lives, until you experience it, you probably can't believe it. I mean, I didn't. I read about it. It's like, okay, maybe other people. No. I mean, I'm there. And I'm stunned. So that's one reason. Amazing exercise endurance. Tests have been done on low-carb/high-fat and high-carb/low-fat diets. And when they're done properly, the low-carb/high-fat diets blow the alternatives away. And we'll talk about why.

So exercise endurance, also muscle building, and recovery is amazing this way. And then, finally, long-term health benefits. I believe that because primitive man, where the human genome was designed, had no access to these dense carbohydrate foods which we in our cleverness agriculturally created and, using industry then to mill the grain, which is even indigestible until it's milled, we created this whole new class of food which, while it has an incredible amount of calories in it and is interesting and appetizing and could be created in all kinds of shapes and sizes and tastes, it isn't what we were genetically designed to consume. And what happens is, when we feed ourselves glucose, sugar, carbohydrate, our bodies lunge for it preferentially. We're all about preserving calories. And lord knows, people who struggle to be a weight that they like wish we were less efficient at grabbing and preserving calories.

So let me - we've got about 15 minutes left, and I've got so much to say. But we can continue this if people are interested. The trick is that you have to bring your carbohydrate intake, the carbohydrate portion of your diet down below about, as I said, 50 grams, which is about 200 calories a day, for some length of time. I believe it took me a much longer time to get into ketosis because I'm extremely trained up in my carbohydrate metabolism. When I'm working with the stair climber that hard almost every day, essentially I am draining myself of all of my glucose and glycogen carbohydrate supply. I'm burning that at that high rate. That's way above the so-called "fat-burning level," which is a much lower level of exertion. I'm emptying my tanks, essentially, and so my body's adaptive response is to increase the size of the tanks.

So it's necessary to bring your carbohydrate intake down and hold it there without exception. The reason is that our metabolism really doesn't want to give up carbohydrate. It is glucose. And it's funny, too, because we talk about complex carbohydrates as if they're somehow really complicated. The term actually means more than two molecules of sugar. A monosaccharide is a sugar that has a single molecule, and we know what they are. Glucose, fructose, and galactose are single-sugar monosaccharides. Disaccharides that have two sugars are sucrose, lactose, and maltose. Sucrose is made of a glucose and a fructose, lactose from a glucose and a galactose, and maltose from a glucose and a glucose. Everything else that is more than either one or two sugars is, by definition, a complex carbohydrate. All they are is more sugars, and in this case it's glucose, more glucose molecules strung together. It looks like rice; it's just sugar. It looks like bread; it's just sugar. I mean, that's all it is. And potato starch is just a complex carbohydrate.

What happens when we eat any of that is that our body preferentially selects that for its energy metabolism and shuts down our fat burning. The mistake that many dieters make is they bring down all three components of their diet. They eat less, the idea being calories in/calories out. We're basically a simple thermodynamic machine. So we're burning X number of calories a day. We're taking in X number of calories, or Y. And if X is bigger than Y, then we'll lose. If Y is bigger than X, then we'll gain. So what many people do is they eat less. They, like, don't have ice cream for dessert. Well, ice cream's got sugar, so there's carbohydrate. It's got fat from, obviously, in the ice cream. And there's dairy protein in there also. So they don't eat that, they bring all three of these parameters down.

Typical dieting is difficult because, after some length of time, your body has used up its ready supply of glucose and glycogen, and it's beginning to have a hard time regulating blood sugar. But there is, in fact, the authors, Phinney and Volek, who wrote "The Art and Science of Low Carbohydrate Living," they consider that there is a defect in an aspect of human metabolism which is our livers will not start generating these ketones until we get under that magic threshold. It's not a linear function. There's a threshold at this 50 grams of carbs per day. If we tease our metabolism, specifically our liver, with more than that every day, it sits around waiting for its daily injection of carbohydrate. It doesn't switch over.

It's only if we hold this level below this magic number and then wait, without exception, because again our body does not want - our body is all about preserving fat, evolutionarily, not burning sugar. So you have to deny it sugar. And when I say "sugar," I mean carbohydrate because that's all it is. And after some length of time, and people who do the so-called "Atkins Diet," which I regard as maybe an extreme form of this - and again, I'm not looking at this as a short-term thing. This is, for me, a way of life that I've just discovered and didn't expect to. People who do this talk about maybe four or five days until they start producing ketones and notice it through this ketogenic aspect of the liver.

What happens - I want to get this out real quickly - is that all of our body can burn either glucose or fat except our brain. Our brain is unique in that it's only able to burn glucose and ketones. And this ketogenic aspect, or the ability to metabolize ketones by our brain, was only learned in '67, so very recently. It was known, though, much further back, that for some reason these kinds of diets helped with childhood epilepsy. And so the notion of a ketogenic diet was developed and perfected for kids where pharmaceuticals were insufficient and weren't able to prevent seizures. It turns out that feeding their brains with ketones rather than glucose hugely solved this problem. But also we have learned that one of the symptoms or one of the physiological aspects of Alzheimer's is that our brains become less adept at burning glucose, and so people with mild Alzheimer's who

are on ketogenic diets end up doing much better because their brains don't lose the ability to burn ketones.

So there's three energy substrates: glucose, fat, and ketones. As long as we're feeding glucose in our diet, as the standard American diet does because carbohydrate, which is just sugar, is so prevalent, our bodies are not producing ketones, and they're not burning fat. They're holding onto the fat for a rainy day. Evolutionarily, our bodies are very jealous of fat. We typically only have a pool of about 2,000 calories of glucose in our bodies at any time. That's both in the form of glucose in our circulation, our blood sugar, but there's not much of that actually in circulation. It's also stored in a form called "glycogen," a lot of it in our liver, but also all throughout our muscle cells and other cells. So that's available.

When we diet and begin eating less and specifically hold back carbohydrate, the supply of glucose begins to dry up. And if we keep carbohydrate below this magic threshold, the problem is that our brain needs glucose. And our brain is unique in having no short-term sugar supply at all, no short-term energy supply. If it doesn't get what it needs, you're in a coma. So supplying our brain with glucose or an alternative, which in this case is ketones, is crucial. So if we starve ourselves of sugar by refusing to eat carbohydrate, after some length of time, depending upon the specifics of individual body metabolism, our liver will say, okay, we've got to get going here producing ketones. Insulin will have been held low for a long period of time because it rises in response to blood sugar rises, which is mostly caused by consuming carbohydrate. Insulin will be low. There's another protein called "glucagon" which our pancreas then secretes, which is the message for our cells to begin releasing their stored fat. That comes out into our circulation as free fatty acids, which our cells can burn. The problem is they're not used to it because they haven't been having to be used to it.

So our liver, however, immediately begins burning these free fatty acids, chopping them up in pieces to create ketones. Free fatty acids are, well, "hydrophobic" is the word. They're not water-soluble. So they bind to albumin in our blood, which is a protein, the most prevalent protein in our blood, that allows them to be carried through the blood. But as we shorten these fatty acids, they become increasingly water soluble until, when they're very short-chain fatty acids, they can live in water by themselves. That's important because only water-soluble material is able to cross the blood-brain barrier. So glucose is water-soluble, as are these ketones.

So our brain begins getting its supply of ketones. All of our other muscles and body cells are also able to burn ketones. So initially our brain is competing with our untrained, un-fat-burning-trained body, for this source of ketones. Thus the reason I was initially producing so much of them. What happens over time, though, is there is the genetic expression, as a result of lack of glucose and the availability, of free fatty acids in our blood, which then begins to cause our cells to synthesize enzymes for metabolizing fat. We get better at burning fat. And this is the so-called - there's something sometimes called the "Atkins Flu." It can take, like, from several weeks to a month for, even after we get into this mode of ketosis, for our body to adapt to fat-burning completely.

What ends up happening is, I mentioned, remember, there are three types of ketones: the acetoacetate, the beta-hydroxybutyrate, and acetone. Initially our cells are burning both of those. But our muscle cells learn to only burn the acetoacetate. And actually it's oxidized to the beta-hydroxybutyrate. So our muscles end up producing the ketone that our brain most wants and is able to metabolize.

So that's where I am at this point. I didn't expect any of this. It's changed my experience of eating for the rest of my life. It's a sacrifice. As I said to you at the beginning of the podcast, Leo, I talk about this as life over on the other side of the sugar hill. I mean, there is a steep climb you have to make. You have to change the way you eat in order to

get this. But there are many things going on. For example, I was breathing so much easier because there's something called the "respiratory coefficient." Carbohydrate, sugar, has a respiratory coefficient of 1:1, which is the amount of CO₂ produced versus oxygen consumed. Protein is 0.85, so you only produce 85 percent as much CO₂ as oxygen. Fat, which I am now burning, is 0.7. So I was producing only 70 percent of the CO₂ when I'm in my last most recent stair climber workout. Actually I should say I did it again yesterday to verify all of this was still the case, and it was.

We breathe for two reasons: to get oxygen in and to get rid of CO₂. CO₂ is acidifying, and we need to keep our blood pH balance. So the reason you huff and puff when you're doing exercise work is as much to get rid of carbon dioxide, to exhale the CO₂, as it is to bring in oxygen. And so when you're burning fat, you're producing only 70 percent as much CO₂. Thus my respiration was completely changed.

Leo: And this will be continued at a later date because we are out of time. I wish I had more time to give you.

Steve: Let's pick it up next week.

Leo: We can do this again next week.

Steve: I'd like to talk to you about it.

Leo: We'll give the disclaimer once again. Steve is not a registered dietician and nutritionist or a physician. Although being a physician is often, while I think we often believe physicians are god, they're very rarely trained in nutrition. So that actually isn't a very good qualification for any of this. But you should consult a medical professional before embarking on any new dietary program. I think what's interesting in this is that Steve is a very smart guy who spends a lot of time thinking about this stuff and has done a lot of research on it. So I'm finding it fascinating. I hope you are, too. We will make this TWiT Special #124, if you want to download it and listen again or give it to somebody. I'm sorry, Steve. Go ahead?

Steve: I was just going to say that anyone who's making a substantial dietary change, if they have any kidney problems or liver problems or anything that they know makes them different, please, please, please talk to your doctor.

Leo: Ketosis can be dangerous for people who have a variety of medical conditions. This isn't something you should embark on lightly.

Steve: Correct. Again, I would say make sure you do this responsibly. Talk to your doctor. I keep reading that, so I wanted to make sure that I passed that along. There's a lot of other chemistry and dynamics that are interesting about this. And it really does change everything.

Leo: Thank you, Mr. Steve Gibson. Steve does the Security Now! program every Wednesday. I'm sure we'll have some Q&A on this in Security Now! on Wednesday,

11:00 a.m. Pacific, 2:00 p.m. Eastern, on TWiT.tv. And we will - let's do this again next week at 2:00 p.m. What do you say?

Steve: I would love to, Leo, yes.

Leo: 2:00 p.m. Pacific, 5:00 p.m. Eastern. Part 2. We've been up the sugar hill. Now we'll go down the sugar hill.

Steve: Well, yeah. I needed to get all this out. Let's you and I talk about all of this because there's a lot more information that I have. And I think you and I discussing it will be a great way to bring that out.

Leo: Very good. Thank you, Steve.

Steve: Thanks, Leo.

Leo: Thank you, everybody, and we'll see you next time.

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