Understanding the Role of Reductive Stress in the Development of Chronic Disease
A Special Interview With Brad Marshall
By Dr. Joseph Mercola

Dr. Joseph Mercola:

Welcome, everyone. Dr. Mercola, helping you take control of your health. And today, we are joined by Brad Marshall, who has some notoriety in the space of understanding molecular biology with respect to optimizing biology. Let's put it that way. In fact, he has extraordinary insights and he's one of the few people I know who actually understands reductive stress. There's really only three people I know aside from me, Georgie [Dinkov], Brad and Ray Peat. There are others, but I don't know anyone else but those three people.

It's a really complex topic and we're going to try to simplify it for you because most people don't get – Even really intelligent people like Chris Masterjohn I interviewed recently. He didn't understand it and I wasn't going to debate him. But reductive stress is a really important topic because it's fundamental to optimizing your biology. And we're just going to have a delightful conversation today about that and so many other things. I have no idea what they're going to be, but I know it's going to be fun and you're going to enjoy it. So, it's going to help you understand fundamental biological principles that are not widely appreciated or certainly even understood, that for the most part contradict almost everything we've been taught about biology.

I know that's quite an astounding statement, but it's true. And we'll hopefully convince you with enough compelling data points to connect the dots because it's all about connecting the dots. And you may not believe us today, but you probably will down the road. So, we're just going to give you a peek into the future of what it's going to be. And there's a benefit here because when you understand biology at a fundamental level, you can implement that knowledge to optimize your own biology in ways that we never really understood or appreciated previously.

So, with all that said, I'm going to let Brad introduce himself and give a little bit of his history. He has a fascinating history. He's been on many other people's podcasts before. I think Paul Saladino, M.D., was one, and Tucker Goodrich and others. He's quite the intellect, and I have to give, I guess, a disclosure perhaps that I've just hired him to be a researcher and really lit a fire under him to pursue his passion, which is really molecular biology research. And he's going to help uncover some fundamental things that are not known yet. So, we're funding some projects. I'm funding some projects, and he's going to do the research and probably head up a lab that I'm putting together, so at least [that's] what it looks like now. So, with all that said, welcome and thank you for joining us today, Brad.

Brad Marshall:

Hi. Thanks for having me on the show. Yeah, so who am I? I went to Cornell University for molecular biology, and I'm a boy from the country. I'm from upstate New York. My grandparents were farmers. I grew up in rural America, went to Cornell, learned genetics, and I

have a lot of interests. After school, I went to Memorial Sloan Kettering Cancer Center and worked in a tissue culture lab and cloned genes and learned the art of molecular biology in the lab. And at that point, I went to the French Culinary Institute because I'm very interested – I love to cook, I'm interested in food. I didn't know a lot about cooking before I went to the institute, and I realized there that working in a French kitchen and working in a molecular biology lab are not really that different. The recipes and the protocols are very precise. You weigh it. Everything is measured by weight and by proportion.

Anyway, from there, I went on and I worked at the Berkeley Drosophila Genome Project for the gene ontology project really, and there I was involved more in the software side of things. We were doing the drosophila, which is a fruit fly genome [that] had just been sequenced, and we were building software to help biologists parse through all of this data and annotate what are genes? What are these genes involved? What do we know about these genes and how do we keep track of all of that? And then I actually worked mostly on the software for the gene ontology, which is where we have a vocabulary where when you say, pick an enzyme, SCD-1, that when you use that term you know that you're talking about the same gene in a drosophila, which is a fruit fly, versus C. elegans, which is a nematode versus yeast versus humans versus mice.

So, it's a way of knowing that people working on different organisms are talking about the same gene. And so, at that point, I kind of did what appeared to be kind of a strange move, but I moved back to upstate New York, bought a farm and started raising hogs because, like I said, I'm also really interested in food. And we moved closer to our families, my now ex-wife and I. And we bought the farm here, started doing all this stuff in agriculture, and one of the things that came out of that was I started to realize I had, already at this point, I was interested in reducing my polyunsaturated fat intake, and that had come from reading work on the Weston A. Price website and the work of Sally Fallon [Morell].

Dr. Joseph Mercola:

What year was that, Brad? What year was that?

Brad Marshall:

That was 2004.

Dr. Joseph Mercola:

Wow. 20 years ago, you were doing the low PUFAs (polyunsaturated fatty acids).

Brad Marshall:

Yeah, and I think maybe it was a little later than that, but I think even at that point, I was also perhaps being influenced by this website of this guy named Dr. Mercola. I don't know when that website started, but it's been around a long time.

Dr. Joseph Mercola:

Yeah. But no, listen, the reason I say that is because I really didn't understand the dangers of PUFAs. Not really. Not until, I would say, 2018, maybe '17, but certainly no sooner than that, at least to understand it at the level I do now that it's the most – And I'm sure you would agree, but if you do disagree, let me know. I think we both agree that it's the most pernicious metabolic poison in our diet right now. More so than glyphosate.

Brad Marshall:

Yeah.

Dr. Joseph Mercola:

It's linoleic acid.

Brad Marshall:

Yes, I believe that it is. I think it's a little more complicated-

Dr. Joseph Mercola:

Yeah, of course.

Brad Marshall:

-than some people do, I think.

Dr. Joseph Mercola:

Yeah. And let me interrupt here your story, because you didn't mention it, and it took me a while to understand it, what makes you so special. Because many people have your pedigree, but not many people read the number of papers that you do. You're an OCD (obsessive-compulsive disorder) about reading papers and the literature, and you know things and you find things that very few people know and understand. And you're going to reveal some of the discoveries you've done by reading the literature. You're a voracious reviewer of the literature in molecular biology, and that's the way that you make innovations and advancements. So, it's quite spectacular. I've never seen anyone that's such a voracious consumer of the scientific literature. So, congratulations.

Brad Marshall:

Well, I do. When I go through the literature, I like to answer very simple questions. Like I find myself saying, "What do antioxidants do? What do they really do? What does it mean?" Because all these terms get thrown around, right? What is inflammation? What do you mean when you say something is inflamed? What are we actually talking about? Because all these terms, they're used in a thousand different ways, and the nomenclature is never very clear. And so, I like to just see if I can distill it down and just understand the basic things. And sometimes you have to read a hundred papers or 500 papers just to clarify what really is an antioxidant.

And so, I try to stick with basic concepts, but every paper, of course, is layering more data on top of that. And you have to stay – You can't pre-decide it's this way. You have to always stay flexible because a lot of times you're wrong, or more commonly you're sort of right, but it's a little more complicated than that, and there's aspects of it that you haven't thought of. And then ultimately, you're starting from these small things that you know, like you say, you're trying to build a bigger story. And just real quickly, one of those things that I did notice when I was – the reason I brought up the pig farm is that – So, I was trying to avoid polyunsaturated fats, and I was noticing – Because I was raising these pigs and I was feeding them, and then we had a butcher shop where I was cutting the meat, I could see very distinctly that the firmness of the fat would change based on what I fed the animals.

I could also very distinctly see that the firmness of the fat would change based on the genetics of the animals. And so, I was seeing these very distinctive shifts in the fat composition between based on what I fed them and what their genetics were. And you can look in the literature about pigs from the late 1800s saying, "Well, if you feed certain foods to the pigs, they get soft fat." And these are inevitably things that had a lot of linoleic acid. So, one of them was chufas. Another one was peanuts. They said, "If you finish the pigs on peanuts, they'll have soft fat." And that is because that linoleic acid from the peanuts will accumulate in the pig fat. And then you just get this soft, oily fat, and you can't slice the bacon, and it's just generally unappealing.

And so, they talked about how you firm up the fat, and basically, they would feed them starch to firm the fat back up in the eight weeks before the pigs went to market, if they were feeding them peanuts, for instance. And so, I kind of had this idea, I was like, "Oh, most things that you eat in your diet don't accumulate." If I eat extra protein, it doesn't change the protein composition of my muscle fibers, let's say, because they're all very tightly controlled. But the polyunsaturated fat is the one thing that you eat in your diet that can really sort of bioaccumulate in the organism. And so, I thought that was really interesting. And I stopped running the pig farm and the butcher shop around 2019. And about 2018 was when I really got back into the literature and have been trying to untangle this mystery, sort of starting with the mystery – not the mystery of the pig fat, but that was kind of the gateway of how does this really work, the fat saturation?

I'd also been reading the work of Peter Dobromylskyj, who writes the blog Hyperlipid, and he was talking a lot about reactive oxygen species (ROS) production in the mitochondria. So, when we burn our calories, we inevitably wind up creating these reactive oxygen species, which is interesting to me as a biologist, because I was taught in college that reactive oxygen species are bad. They do damage and they hurt the cells. And then I start reading his blog and he's saying, "Well, no, they're actually important signaling molecules, and they affect insulin signaling and they affect energy in and energy out of the cells." And I thought that was interesting. And so, I've just gone down that rabbit hole, and now I realize that this whole topic of reductive stress, NAD+ (dicotinamide adenine dinucleotide+) and NADH (nicotinamide adenine dinucleotide hydrogen) and fat saturation are all joined at the hip. You can't separate the topics. They're all connected. If you pull one lever – And just to be clear, what I mean by that, when we talk about reductive stress, which sounds very complicated, and I think I can-

Dr. Joseph Mercola:

Well, it is. It fundamentally isn't, but it's mind-blowing.

Brad Marshall:

It fundamentally isn't. But I think it's simpler than – I think the term is needlessly confusing-sounding. It essentially just means that you have too many electrons. You have too many mobile electrons in the cell. And so, we eat our food. Well, what is a calorie? Calories are just energetic electrons that live between carbon and fat and carbohydrates. They're mostly carbon and hydrogen. Carbohydrates have oxygen as well. But the calories in the food are just those electrons between the carbon and the hydrocarbon bonds, and this is why when they talk about hydrocarbons that you burn in your car, they have energy for the same reason. And of course, hydrocarbons came from living animals. That's just fat that's buried underground, really. And so, those electrons between the carbon and the hydrogen, that's where the energy is. And so, we have these systems where the electrons kind of flow through the cell, and we use that electron flow to create ATP (adenosine triphosphate). And the ATP moves our body.

And the electrons, instead of moving through wires, they move on these electron carriers, which are things like NAD. So NAD, when it has electrons is NADH, and when it loses the electrons, it's NAD+. And what you want is you want a balance of NAD+ and NADH, and then the electron flow works. And what happens is we get too many electrons in the system. We get too many NADH and not enough NAD+. And that can happen because we're allowing too much fuel into the system. That's usually why it happens. And so, to use another analogy that I think is a really good one, cars used to have carburetors, right? Chainsaws, I think, still have carburetors. And what a carburetor is, is it takes in fuel and it takes in air, and it mixes the fuel and the air together.

And if you get the right amount of fuel and the right amount of air, it burns cleanly and the engine runs. But if you get too much fuel and not enough air, that's called a rich fuel-to-air mixture. It's too rich, it's too much fuel, and it doesn't burn cleanly. And that's essentially what's happening with reductive stress. And that's essentially what's happening with metabolic syndrome. People might've heard of it as energy toxicity, or people might've heard of hypoxia or pseudohypoxia. And they're all pretty similar concepts.

In our bloodstream, we have glucose, we have fats, we have amino acids, and they can all get used for fuel. And if they're too high, they're all going into the mitochondria together. And simply, you get those carriers that move the electrons around. You can think of them like taxis. It's like everybody's getting off at the airport and you got to get to the sports game or stadium or whatever. And if all of the taxis are full of people and you're the next one trying to get in a taxi, there are no taxis left. The taxis are all full. That's reductive stress. It means that the electrons that are waiting to get burned have nowhere to go, and it builds up. And suddenly you have, whatever, a crowd of angry people, and it's not working. And so, it really is just electron flow.

Dr. Joseph Mercola:

Well, let's stop there because – Thank you to be leading us to this point. There is damage that occurs. And that damage is you have this surplus of electrical charge, negative charge, and that can cause secondarily oxidative stress, which it's not easily understood, but that's what the cause is. Fundamentally, it's the cause of most oxidative stress. It's not these free radicals. It's the surplus electrons that cause the oxidative stress.

Brad Marshall:

Right. And so, what happens in the mitochondria is that – so now you have all this NADH, and they're trying to drop their electrons into the electron transport chain, which is-

Dr. Joseph Mercola:

Let's still add some more context here. So NADH is the reduced version. It's reduced because – it's kind of difficult to follow, but because it has extra electrons.

Brad Marshall:

It has the electrons.

Dr. Joseph Mercola:

Electrons are negative charge, so that's why it's called reduced. But there are also other molecules, like beta-hydroxybutyrate is reduced, lactate is reduced, ubiquinol is reduced, FAD2 (fatty acid desaturase 2) is reduced. These are all molecules that have – it's a redox molecule. It's an oxidized version and a reduced version. So, you're talking about the reduced version, and that a surplus of those reduced molecules is big trouble, big trouble.

Brad Marshall:

Right. It's big trouble. It's big trouble. But again, it's just they go back and forth. They have the electrons, they don't have the electrons, and they give the electrons to other molecules. Think about it like a cab. Either you've got a passenger or you don't. When you've got the passenger, when you've got the electrons, you're the reduced version. You drop that passenger off, you drop those electrons off, you can pick up another electron again. And there's just a network of these things, picking up electrons, dropping them off. When you have the electron, you're reduced. Drop the electron off, you're oxidized.

Dr. Joseph Mercola:

Let me stop you here, too. I know you're [inaudible 00:19:04], but I'm sorry for the interruptions, but it's just an important point because I've been promoting grounding – "earthing" this is sometimes called by Clint Ober, who popularized this concept about 20 years. And Clint is a wonderful soul, genuine human being, full of love, but he doesn't understand how grounding works. He thinks that it's picking up electrons from the surface of the earth, and that is exactly how it doesn't work. It's the exact opposite. And I've discussed it with him, but he still hasn't embraced it. It reduces reductive stress.

Brad Marshall:

Yeah, I agree with you that grounding, the goal really is to get rid of the electrons and to move the electrons through. From a very basic perspective, the problem with metabolic syndrome is we're not – Our fuel, we need fuel to live. We need fuel to have energy and to have ATP. But the

problem comes when we're not taking those electrons from that fuel and efficiently moving them through the system. My mantra is [to] follow the electrons. I was thinking when we do the lab, we should have a big poster that just says, "Follow the electrons."

But that's real. So, we talked about how does reductive stress cause problems? Why does reductive stress lead to oxidative stress? And it's actually not – That sounds like a really complicated hard problem, and I didn't understand it at first. And then the more I thought about it, I was like, "You know what? It's not even that hard." So, what happens is the NADH is carrying the electrons and it carries them up in the mitochondria to this thing called the electron transport chain. And that makes the ATP, which we run our bodies. But the first step of that is the NADH hands the electron, the pair of electrons off to this thing called Complex I.

And what happens is if you have too much NADH, this is called electro pressure. You've got too much of this NADH, and you've only got so much of this Complex I. And if you've got six molecules of NADH all trying to hand their electrons off to the Complex I at the same time, they can't all make it through. You essentially have a bottleneck. And these electrons, they want to move to the next thing because they're in this very energetic state, and they want to jump. And if there's not enough throughput for them all to get off, then some of them are going to come back out. They're not going to make it into Complex I.

And that's what creates superoxide, which is the free radical, the reactive oxygen species. And the superoxide kind of starts that chain of what potentially can lead to oxidative damage. Now, it doesn't necessarily lead to oxidative damage. In fact, it can be helpful. But in the scenario, if the reason that you're generating superoxide is because you have too much NADH and all of the electrons are being funneled towards Complex I and you're generating superoxide there, that's bad and that leads to oxidative damage ultimately. Because you're going to generate so much superoxide there that your antioxidant systems are going to become overwhelmed. You're going to have this long-term increase in superoxide and in hydrogen peroxide.

Dr. Joseph Mercola:

Let me just interrupt for a moment. And the reason superoxide is being generated, just to connect the dots, is that there is oxygen in the mitochondria.

Brad Marshall:

Yes.

Dr. Joseph Mercola:

It's supposed to be there because it's oxidative phosphorylation. And that's why we convert fuel so much more efficiently than bacteria. And the oxygen is there waiting to be used. The electrons are ultimately transferred to it, but it has to be done through the electron transfer chain. And if it's backed up, those surplus electrons are going to attack oxygen directly. So, that creates the free reactive oxygen species. It's there from the surplus of electrons that didn't make it through the electron transfer chain, that are attaching prematurely to oxygen.

Brad Marshall:

Right. And so, all superoxide is it's an oxygen and it has a single additional electron. And by the way, the reason that we say "things get oxidized," when we say things get oxidized, it means they lost an electron or they lost a pair of electrons. And the reason that we call it oxidation is that oxygen loves to take electrons. Oxygen is extraordinarily electrophilic, they call it. It loves electrons. And the only reason, by the way, that oxygen is without its electrons in the first place, remember, is that a plant used the energy from the sun to strip those electrons away from oxygen in the first place. That's why we have oxygen in the atmosphere. And then the animals have learned to use this as a trick to generate more energy. And so, now you have this free floating O2, which it is stable, but it wasn't sort of happy to get there in the first place, and it would love to kind of get its electrons back.

And so, now you have this situation at Complex I. You have all these electrons. They can either go through Complex I, sort of the correct way and make ATP. And ultimately, at the end of the electron transport chain, they join back up with oxygen, and it converts oxygen to water. But yes, prematurely, there's still oxygen around and the oxygen will soak up the electrons any way that it can get it. And so, if you have all these NADH and all these electrons, and they're all pushing and jostling at Complex I, inevitably some of those are going to end up on oxygen and form that superoxide, which is – Well, superoxide is a very interesting, important and useful molecule, but if you generate a lot of it at Complex I, that's the wrong way to do it.

Dr. Joseph Mercola:

Yes. And what causes much of the pathology that we see. It basically decreases your mitochondria's ability to generate energy. And that's the crux of almost every single disease we have. And I know this may seem overly complicated, molecular biology. Why the heck are we talking about it? There is a reason because it has an impact on the foods that you eat and the type of foods you eat. And we're going to tie the knots together, the bow together rather, and help you understand this, so just hang in there. This is still relatively simple, I think you've done an excellent job at simplifying a really potentially complicated topic.

Brad Marshall:

We've just explained why superoxide is bad if you generate it at Complex I. Now here's the problem is that another thing that, when it is very actively working, creates a superoxide, or really, it creates hydrogen peroxide, which is another reactive oxygen species, is pyruvate dehydrogenase. Now, pyruvate dehydrogenase is the limiting factor in burning glucose. So, you have blood glucose and it converts it to acetyl-CoA, and that's a crucial step. You can't burn glucose oxidatively if pyruvate dehydrogenase isn't working. And while it's working, it's making superoxide. And so-

Dr. Joseph Mercola:

And let me just set that back a little bit because pyruvate is a three-carbon molecule, glucose is six, and there's another enzyme that breaks glucose down into two molecules of pyruvate. And then ideally, pyruvate wants to be burned in the mitochondria, but it can't do it directly. It has to

be converted to acetyl-CoA. And the enzyme that does it is pyruvate dehydrogenase. If it doesn't, then it backs up and it forms the reduced version of pyruvate, which is lactate, which is a problem. And this is what goes up in cancer. This is what goes up when you have low NAD, it connects. Pyruvate and lactate are what's called a redox pair.

Brad Marshall:

Right. That's exactly right. And so, you want to keep lactate low. You want to be able to oxidatively burn glucose. And what happens is – and here's the crazy part, and this is the part that connects all of the dots, and it's a little bit hard, but there is an enzyme in the mitochondrial membrane called NNT. And I'm not going to try to say the full name.

Dr. Joseph Mercola:

No, don't even think about it.

Brad Marshall:

Nicotinamide [nucleotide] transhydrogenase, I think, let's say. Something like that. And what it does is it uses the superoxide to regenerate NAD+.

Dr. Joseph Mercola:

Wow. That's a useful thing.

Brad Marshall:

Right. And there's a whole series of steps, there's a whole series of steps by which this happens. It essentially uses something much like glutathione and blah, blah, blah, blah, blah. But ultimately, the end product is that the reactive oxygen species generated by pyruvate dehydrogenase can be used to regenerate NAD+. And that is a sort of magic. And what happens is with NNT, when everything is functioning right, the more reactive oxygen species that you can produce, the higher your metabolic rate can go. So, when you create reactive oxygen species and that oxygen becomes superoxide and ultimately is converted back to water, you're still burning oxygen. That's still [the] metabolic rate. The electrons are still making their way ultimately back to oxygen. And we have this circuit in the mitochondria that can do that when things get a little overheated. It's like a pressure relief valve, this NNT. And so, that's a really neat trick.

So, then the problem comes when you have this buildup of acetyl-CoA in the mitochondria. And so that's kind of the second part of this reductive stress. And so, all of our foods – like you say, glucose is converted to acetyl-CoA, fat is converted to acetyl-CoA, a lot of amino acids are converted to acetyl-CoA. If you have too much of all of these fuels flooding into the mitochondria all at the same time, you get this buildup of acetyl-CoA. And then there's this process that happens, and it's called acetylation, and that's where basically you have all these enzymes and they're working away. And these acetyl groups, if they build up too high, can just jump onto the enzymes, and the enzymes stop working. And one of the first enzymes to get

acetylated is NNT, the magical enzyme in the mitochondrial matrix that converts the reactive oxygen species into NAD+.

And when that thing gets acetylated and turns off, now you've lost that safety relief valve. Now, acetyl-CoA builds up even more. Now, NADH builds up even more because NNT isn't working. And that's when you have the real true train wreck. And that's when NADH builds up, and now you're having frank oxidative damage. But that oxidative stress and that damage started with rising NADH levels. When NADH levels rise, the metabolism slows down a bit. The acetyl-CoA can't be burned fast enough, those levels rise, then you get acetylation, and now you've got real problems. The other thing that gets acetylated very early in the process-

Dr. Joseph Mercola:

Before we go there, what's the real problem? The real problem is you're reducing the efficiency and the ability of your mitochondria to produce cellular energy. So, you are fatigued. Your brain doesn't have the energy it needs. It's 2% of your body weight, it consumes 20% of your energy. And you're tired. You don't think clearly. Your immune system is impaired because they need energy, too. So, every process in your body needs energy. And if your mitochondria aren't producing it, you're going to be impaired, sometimes quite seriously. And it's this chronic mitochondrial disability, or dysfunction would be the most accurate, that typically is related to metabolic flexibility or your body to seamlessly burn glucose efficiently in your mitochondria. And this is all related to this reductive stress. This is why this is such an important topic.

Brad Marshall:

Yeah, yeah. Right. And I think that the fact that the oxidative stress – because everybody has heard of this oxidative stress, and they know that one of the reasons the mitochondria isn't functioning is because the enzymes really do have oxidative damage. But the key thing to understand is that process begins with the reductive stress, and it begins with too much NADH, and it begins with too much acetyl-CoA, and that just leads to slowing everything down. And as you were saying, the other enzyme that gets acetylated very quickly is succinate dehydrogenase, which is Complex II. And so, that's the FADH2 (flavin adenine dinucleotide), that's the other main input of electrons into the mitochondria. So, when acetyl-CoA levels build, Complex II gets turned off, and then, like you say, the whole system slows down. You can't efficiently create ATP, you can't send electrons through the system, and you've got all kinds of problems.

Dr. Joseph Mercola:

Yeah, and that's the fundamental reason from a molecular biological perspective, why is it – And you did such an exemplary way of describing it. You can obviously relisten to this again because it's pretty straightforward once you don't get confused or avoid that, but it really isn't as hard as you can be intimidated by. It's a straightforward concept, and once you understand that, you can take that action and make positive decisions and choices in your life to make sure that doesn't happen to you, or at least you minimize the likelihood of that happening. So, what is the take home knowledge? What do we do with this knowledge?

Brad Marshall:

Right. So, I know you've been listening to a lot of the work of Ray Peat. I'm kind of what I would call "Ray Peat adjacent." I have started to listen to more of his stuff. Recently, I listened to the clip you sent. I've been on a parallel path and think similar things. And so, one of the things I've been doing, I've been trying to become a more efficient glucose burner. So most of my adult life, I have been more of the keto mindset. And now, I've realized that's probably not the best outcome or not the best way to go about it. So, I'm trying to be better at burning glucose. And so, one of the things I'm doing is I've dramatically increased my starch consumption, and I've been playing around with – There's a very interesting study by The Lamming Lab.

So, I have a YouTube channel, and the last video I made was about what does insulin do? And this is one of those simple questions, what does insulin do? So, you eat a meal, insulin is released, and you have this tension about what gets burned in the mitochondria. And when you consume a meal that generates a lot of insulin, it suppresses the release of free fatty acids from your fat cells. And those free fatty acids are what cells import and they burn in the mitochondria. And so, essentially what the insulin is doing is it's kind of telling the fat to get out of the way because you can't burn fat and glucose at the same time efficiently because of this thing called the Randle cycle. Burning the fat will actually displace your ability to burn glucose. And so, insulin lowers the amount of fat that can enter the mitochondria. And interestingly, it also lowers the amount of branched-chain amino acids that are circulating. And so I, for a long time, was struggling with high fasting blood glucose numbers in the morning, and-

Dr. Joseph Mercola:

You had frank diabetes, right?

Brad Marshall:

Well, not diabetes, but I would be considered pre-diabetic, I think. I would have fasting blood glucose of 115 in the morning, which is-

Dr. Joseph Mercola:

Well, see, in my mind, I know the conventional diagnosis is over 125, but any triple digit fasting glucose is diabetic in my view.

Brad Marshall:

Right, right. Sure. I mean clearly, I had insulin resistance, and so I'm trying-

Dr. Joseph Mercola:

Metabolic inflexibility.

Brad Marshall:

Right. Yeah, absolutely. And so, I've tried any number of different diets to try to get a handle on this, and different supplements. And the fasting blood glucose in the morning was stubbornly

high no matter what I did. And so, there was a paper by The Lamming Lab, or several papers by The Lamming Lab, and they had found that in mice, if you restricted branched-chain amino acids, it reversed the metabolic syndrome in the mice. And I said, "Let's give it a try." And I posted it, I talked about it in a video, and there's a discussion thread. It's a really good one, actually, people should check it out, called r/saturated fat on Reddit. They started doing it, people on there started trying this branched-chain amino acid restriction, and they were getting great results. And I said, "Okay, well, I guess I should do this then," after I posted on the video.

So, I tried it, and what I did was I switched out things like muscle meats and proteins from any grains that I was getting with essentially connective tissues. So, I was doing pork rinds, I was doing bone broth, and I was doing beef tendon. And so, the papers have shown there's this competition between branched-chain amino acids that are high in muscle meats and high in grains, and glycine, which is high in connective tissues, collagen, gelatin. And so, when I did this, I almost dropped all protein sources out of my diet, except for a little tiny bit of muscle meat I was eating, and the bone broth and the collagen and the pork rinds, et cetera. And within about two weeks, my fasting blood glucose was reliably right about 80. I mean maybe that was three weeks. Within 10 days, my blood glucose was out of the single digits. Another week or two after that, I was consistently at 80. And it was-

Dr. Joseph Mercola:

Just about perfect, optimal. You don't want it too low either. That's a problem. 80 is almost perfect.

Brad Marshall:

Right. And that was consuming about – I was still consuming around 3,000 calories a day. I wasn't restricting calories, but I was eating probably 600 grams of mostly starch and some sugar.

Dr. Joseph Mercola:

Maybe we should stop there because you did not say carbs, even though that would be technically correct, because starch is a carb, but you said starch. And starch is a glucose polymer. There's virtually no fructose in it. So, that statement would imply there's some problem with fructose, at least in a person in your metabolic state.

Brad Marshall:

Right. And so, there's a lot of fans of fructose out there. And I'm not sure, Ray Peat was a big believer in fructose and-

Dr. Joseph Mercola:

Well, wait, let me refine that because I've studied his work a little more than you. It was not fructose independently. It was fructose in the form of fruit. It was whole food fructose, it wasn't refined fructose.

Brad Marshall:

Right. And so, it's really sucrose. Fruit really is mostly made of sucrose, which has two sugars joined together. One of them is glucose and one of them is fructose. And the problem with pure fructose is it doesn't activate insulin. So, if you're to eat agave nectar, it's almost pure fructose and you get no insulin signaling from it. And so, you're not going to do the things required to actually burn that fructose if you don't generate insulin. So, don't eat agave nectar.

Dr. Joseph Mercola:

Not a good idea, not a good idea.

Brad Marshall:

But sucrose, I think sucrose is okay. Sucrose generates an insulin response, and of course, starch generates an insulin response. And it's sort of an open question for me whether or not I want to do more sucrose or more starch. And just very briefly, I don't want to go far down this rabbit hole, the concern with sucrose is it activates this transcription factor called TreB P, and that is involved in lipogenic pathways. And that's my specific concern about sucrose versus starch, I guess. My more general way of thinking about it is that when I look at traditional cultures, I see a lot of starch-eating cultures, I see the Tsimané in Bolivia, they live in the rainforest, they eat a lot of starch, and they have very high metabolic rates. And there's a lot of other cultures that ate sweet potatoes and-

Dr. Joseph Mercola:

Let me stop there, too. You said they have high metabolic rates.

Brad Marshall:

Yes.

Dr. Joseph Mercola:

That's an important point. I'm sure that went over the head of almost everyone when you said that, but that is the key. And it's this starch that may actually increase your metabolic rate, and may be the signal that you're eating too much fruit and you need to go to more starch. So, maybe can you expand on that? Because that's the key thing that – Actually, Ashley Armstrong, I just had a conversation with her about that this morning.

Brad Marshall:

Right. So, I like starch. And so, the highest metabolic rate that has been measured in a human population are these Tsimané. Like I said, they live in the Amazon forest. And they eat a lot of cassava and a lot of green plantains, and those are both very starchy foods. They're both very low in protein. They're both very low in branched-chain amino acids. And so, it's a ton of starch and it's not a lot of branched-chain amino acids. And their metabolic rates were something like, I

don't know, 25% higher than – If you took an American with the exact same lean mass composition, and you compared it to the Tsimané, the Tsimané's metabolic rate is 25% higher. And the researchers who did that paper – Spacing on the guy's name, he just wrote a book called "Burn." He's an interesting guy, interesting read.

But they thought that the reason for the high metabolic rate was perhaps that the Tsimané had certain infections because they live in pretty primitive conditions and a lot of them do have certain parasites, and they thought that was the reason perhaps for the increased metabolic rate. But when they really looked at it, it doesn't really explain the difference in metabolic rate. And I think the difference in metabolic rate is that they're eating huge amounts of starch and glucose.

And the thing about that is when you eat a lot of starch and glucose, and you look at what happens in the mitochondria when you're burning the glucose efficiently, it actually lowers the NADH. You get high NAD+, and you get low NADH when you are actively burning glucose. And I think the reason for that probably has to do with what I said before, the pyruvate dehydrogenase generates ROS, and NNT replaces the NAD+. But it doesn't really matter why. The point is, if you're actively burning glucose, you'll have high NAD+ availability, and that's what you need to run your metabolism. Those electrons need to go somewhere, and they want to go to NAD+, and that's kind of how it works. And so, yeah, I'm not sure where I was going with that, but-

Dr. Joseph Mercola:

Well, no, it's an important point because ultimately you do want to have a high metabolic rate because the consequence of a high metabolic rate is the production of cellular energy, which is the big issue. When you have that, that means you have really good mitochondrial energy production and efficiency, which is the opposite of metabolic inflexibility. You are cranking on all cylinders. There's essentially no reductive stress.

Brad Marshall:

Right, exactly. And I got a couple of points leading off of that, and I remember now where I was headed with that in general. So the first one – Of course, as soon as I said that, my brain just emptied, but so let's get back to the saturated fat thing. So okay, here we go. One, there was an old saying in the medical literature, which is that "fat burns in the flame of carbohydrate." You can find this in the 1920s, 1930s if you search PubMed. And I think the reason for that is that when you're burning carbohydrates, you're increasing the amount of NAD+, and fat requires a lot of NAD+ to burn. Fat requires a lot of oxygen to burn basically. And that NAD+ is essentially playing the role of oxygen in the mitochondria, it's oxidizing the fat. And so, I think, burning that carbohydrates generates enough NAD+ that you can actually burn the fat more efficiently and more cleanly. That's number one.

Number two is that, getting back to the example of the pigs, so when I talked about soft fat in the pigs, that's because they have a lot of unsaturated fats. They have a lot of polyunsaturated fats. They also have a lot of monounsaturated fats. And the reason that they have a lot of that monounsaturated fats is we have these desaturase enzymes, and they're taking our saturated fat and they're converting it to monounsaturated fat. And if you look at humans, if you have high

levels of these desaturase enzymes, that is very indicative that you might get diabetes. You become very likely – If you look at a human and what you see is you have low stearic acid, which is an 18-carbon saturated fat, and you have high oleic acid, which is an 18-carbon monounsaturated fat, well, there's an enzyme that desaturates the stearic acid to oleic acid. And it was first reported back in 1964 that if you had this pattern of low stearic acid and high oleic acid, that you were likely to have heart disease.

More recent studies have shown that that pattern suggests that you'll develop diabetes. And so, that's a really bad pattern, and it's caused by an enzyme that desaturates that saturated fat and makes it into monounsaturated fat. And guess what? That reaction of going from saturated fat to monounsaturated fat uses NADH. And so, if you are in reductive stress, if you have high NADH, what happens is you're going to desaturate your fat, you're going to convert a lot of your saturated fat into this monounsaturated fat-

Dr. Joseph Mercola:

And that's likely because you have a surplus of electrons that are looking for a home and they find this home on that desaturase enzyme.

Brad Marshall:

Exactly.

Dr. Joseph Mercola:

It's called SCD-1, I believe, right?

Brad Marshall:

That is exactly right. And just going back to that first point that I made about the pigs was when you look at a book from 1885, it says if your pigs have soft fat, what you want to do in the last eight weeks is feed them starch and their fat gets firmer, the fat gets more saturated. And so, then there was this other study in 1962, these guys went around the world and they looked at human fat composition from all of these different cultures, and the place where they found the most saturated fat in body fat of humans was in Nigeria, in these cultures that were eating cassava and plantain. And these starch-eating cultures in Nigeria in 1962 have the most saturated human body fat that has ever been found.

Dr. Joseph Mercola:

And some people would think that's bad, but you're going to present the argument that's about the epitome of health.

Brad Marshall:

I will make the argument that that shows that, one, you're going to have a fast metabolic rate. If you're mostly saturated, you're going to have a high metabolic rate. Again, we see that in starch-

eating cultures, we see that in the Tsimané, and we see in these Nigerian – Unfortunately, no one has ever measured the fat composition of the Tsimané, but I would wager that it's going to be very saturated, much like the Nigerian cultures that we saw in 1962. And for reasons, that all leads to – We can show in mouse models, if you remove that enzyme SCD-1, the thing that converts your saturated fat into monounsaturated fat, so that means the mice have very saturated fat and they have a metabolic rate that's about 40% higher than are normal mice, and they have very high NAD+ availability. If you then take those mice and you feed them a high fat diet that is pretty unsaturated, this is the standard diet that we use to fatten up mice in the lab, it will reduce the NAD+ availability and it will slow down their metabolic rate.

And so really, it looks like that saturation level of your fat tissue, of your adipose tissue, is a key regulator of both NAD+ and NADH levels and metabolic rate. Of course, like you just said, that is exactly the opposite of what we've been told all these years. But just recently, John Speakman did a paper. They fed mice 15 different fats, and what they showed was a direct correlation between fat saturation and metabolic rate in butter, coconut oil, olive oil, soybean oil. And so, they just showed yes, very directly the more saturated the fat is, the higher the metabolic rate of the mice. And I think that is reflected in our fat tissue as well, because of course what goes into your mitochondria, it's a combination of your stored body fat and your dietary fat, and the more saturated the better in my opinion.

Dr. Joseph Mercola:

Yeah, and this is something that you probably – not you Brad, but you watching this – had probably not heard before because I believe Brad is the one who uncovered this principle. He figured this out because of insidious reading of the scientific literature. He connected the dots, folks, that's what he did, and we're very grateful that he did that.

I was surprised when I connected with him initially because this has actually – there's another part of the story that he hasn't revealed yet. I confronted a really good scientist, [Dr.] Bill Harris, who offers the omega-3 fatty acid index test, probably the best bargain out there to find your fatty acid test, and he presented to me somewhat contradictory results. And that his studies and many others have shown that high linoleic acid levels were associated with a decreased risk of diabetes, which made no sense to me, at least measured in the serum.

Yet, I believed his data because this guy had full integrity and what he reported was true. But it was a paradox as it biologically made no sense because you would predict the exact opposite, because high linoleic acid, which we referenced earlier, is the most significant metabolic toxin in your diet and the last thing you want to do is ever eat excessive linoleic acid. So, Brad, help people understand what you explained to me and the lights went off when you did.

Brad Marshall:

Right. And so, just as we've been saying, when you're in reductive stress and you have high NADH, it drives the activity of these desaturase enzymes, and one of them that we just talked about converts stearic acid to oleic acid, but there's another one and it's called delta-6 desaturase, or D6D, you'll see it abbreviated as. And what that D6D does is it puts – Linoleic acid has two double bonds in it. D6D puts a third double bond into linoleic acid. And that's the

limiting step in linoleic acid being converted to arachidonic acid. And then ultimately, that arachidonic acid gets released from cell membranes, it gets built into cell membranes, and it gets released from the cell membranes. And when that happens, it can get oxidized into all of these oxidized – You know, you hear about oxidized polyunsaturated fats. Well, the polyunsaturated fats can just auto-oxidize for being around superoxide, et cetera. But more of the time, it's being oxidized by our enzymes for a reason. It's part of a system.

And so, when you're in reductive stress, what happens is you start converting that linoleic acid to arachidonic acid. That becomes the oxidized things, like 5-HETE and 12-HETE and 15-HETE, and I name those ones, 5-, 12- and 15-HETE, [which] are specifically associated with [the] risk of cardiovascular disease and all of these other disease states. And the thing about that is when you have [been] spontaneously oxidizing linoleic acid, you don't get a lot of 5-HETE and 12-HETE and 15-HETE. You get 5-, 12- and 15-HETE because of specific enzymes that are oxidizing that linoleic acid. But the end result of all of that is – And guess what, the 5-HETE and the 12-HETE and the 15-HETE feedback and activate things like PPAR-alpha (peroxisome proliferator-activated receptor alpha) and this thing called aryl hydrocarbon receptor, and they in turn increase the amount of these desaturase enzymes that we're making.

And so, you have this huge feedback loop where the polyunsaturated fat is getting oxidized, and that is a signal to convert more of your saturated fat into monounsaturated fat, and it is a feedback loop. And so, the pattern that you see that predicts diabetes, heart disease, obesity is low saturated fat, especially low stearic acid, low linoleic acid because that's all getting oxidized, and high monounsaturated fat. It's high oleic acid, but it's also high palmitoleic acid and other monounsaturated fats. But that, over and over again, is the pattern you see.

If you have high monounsaturated fat and low polyunsaturated fat, that's actually a really bad sign. That doesn't mean that you should run out and start swilling soybean oil. Because the polyunsaturated fat is part of the system that is creating the problem. It's just that it gets burned as part of the process. It's not the thing that accumulates really. And in fact, it's the opposite. So, if you take – There are breeds of pigs that we've selected them to remain very lean. So, over the past 100 years, we've bred for leaner and leaner and leaner hogs. And if you take one of these hogs and you feed them, I think, sunflower oil or sunflower seeds is the study that there is – They fed them like 40% of their calories was sunflower seeds. Those hogs, when they looked at their fat composition, the lard was something like 54% linoleic acid. So, these lean breeds of hogs just accumulate the linoleic acid, they don't oxidize it.

Whereas if you look at a fatty breed of hog like a Mangalitza, those hogs, when you feed them linoleic acid or other vegetable oils, they convert all that linoleic acid to monounsaturated fat and they remain much lower – Their body composition is lower in linoleic acid because – And that's the difference between the hog that remains metabolically healthy and the hog that becomes obese and probably insulin resistant, is that the metabolically healthy hog isn't oxidizing the linoleic acid. And of course, one of the main reasons why that hog would oxidize the linoleic acid is that it's in reductive stress because the reductive stress drives the desaturation of those fats in the first place. It drives the activity of delta 6 desaturase, and that's really the key gating step that is predictive in humans, of diabetes, and results in that pattern of low stearic acid, high oleic acid and low linoleic acid.

Dr. Joseph Mercola:

Yeah, yeah. So, looking at it from a different perspective, what I mentioned earlier with Bill Harris' data, is that high linoleic acid was associated with decreased diabetes, but the converse, which you just explained, is that if this process continues – and this is part of the reason I discuss with you. I'm starting a clinic operation and we were going to test everyone's linoleic acid, serum linoleic acid, and I said, "Well, because we want everyone's linoleic acid level to be low." He said, "Well, it should be." And then he said, "Well, maybe? Maybe not." I said, "What, what?"

Brad Marshall:

It depends on why it's low.

Dr. Joseph Mercola:

It depends on why it's low, and the devil's in the details and you've got to look into the other things. So, one of the things I'm doing in this new clinic is really – I think anyone who has a significant amount of intelligence and understands biology will not argue with the fact that mitochondrial function is the end-all and be-all in assessing health. The problem is we don't have really any good direct markers of that. So, I'm in the process of securing an exclusive license to use the gold standard test, which is the seahorse assay to measure this in people.

In addition, part of the lab that you're going to head up, which is identifying redox pairs measurement in the lab that you're creating that we can submit to determine essentially the redox potential of the tissue, and we'll do that by measuring a few pairs. So, why don't you go over that and explain why this indirect marker of essentially NAD+ – because if you know the redox potential, you should be able to have a strong correlation or [a] really good idea what NAD+ is without measuring it.

Brad Marshall:

Right. You have two compartments in the cell. You have the mitochondria and then you have the cytosol, which is kind of everything else. And we have these enzymes that they're really just flipping the electrons back and forth. So, you mentioned before, in the cytosol, when we make pyruvate, when NADH is high, one of the things you can do with those electrons is there's an enzyme and it'll stick those electrons back onto pyruvate and it'll become lactate and you can export the lactate. So, if the cytosol of a cell is high in NADH, what you can do is you can make lactate or you can desaturate fat. Those are your options to get rid of some of the NADH. In the mitochondria, if NADH is high, what you can do is we make ketones. This especially happens in the liver. The liver makes these ketones. And if you first make one called acetoacetate, and that's actually the oxidized version of the ketone, and then there's an enzyme that if NADH is high, it can stick those electrons on it and make it to beta-hydroxybutyrate.

Dr. Joseph Mercola:

Which is typically thought this is confusing, especially those – you and I both followed keto for a while, and the higher your ketone levels, essentially the healthier you were, so it contradicts that.

Brad Marshall:

Well, sort of. But what you have to remember is that what's telling you your NADH to NAD+ balance is not the total amount of beta-hydroxybutyrate, it's the ratio of acetoacetate to beta-hydroxybutyrate. And I'm not entirely sure how that changes in ketosis. We'd have to look that up, but-

Dr. Joseph Mercola:

Yeah, no one's really even acknowledged that that's an issue.

Brad Marshall:

Right. Yeah, right. For sure.

Dr. Joseph Mercola:

They're just making assumptions. They understand NAD is an issue, but they're just [making] the assumption that if you're generating ketosis, you're burning fat effectively and efficiently, and that's the ideal state. And there are many people, that's their mantra. That's what they believe wholeheartedly.

Brad Marshall:

Right.

Dr. Joseph Mercola:

Yeah. So, that's not truthful.

Brad Marshall:

And the other thing to point out is that these ratios, like the acetoacetate to beta-hydroxybutyrate ratio, you can find them talking about this in papers from the 1950s as markers of mitochondrial NAD+ to NADH ratio. So, this concept has been known for a very long time. It's just that it's only sort of recently that we've become – Well, some of us have become very aware that this is an acute part of the problem, the balance of the NAD+ to NADH. Yes, and you can sort of read that ratio reflected in acetoacetate to beta-hydroxybutyrate. And for the record, what we should also say is NAD+ and NADH themselves are very difficult to measure.

Dr. Joseph Mercola:

That's being kind.

Brad Marshall:

Right. And so, these other things that we can measure in a simple blood test give you a much better idea about your cellular redox balance without finding a way to measure the actual [inaudible 01:05:56]-

Dr. Joseph Mercola:

Well, that's a good comment. Let me get a prescription from my doctor and go and get that measured, Brad. I'm going to go jump on that and do that tomorrow.

Brad Marshall:

Yeah.

Dr. Joseph Mercola:

Please respond to that.

Brad Marshall:

Yeah.

Dr. Joseph Mercola:

You can't do that. Or you can, but it's incredibly difficult and very, very expensive.

Brad Marshall:

Yeah, no. Oh, you're right. Yeah, the acetoacetate test especially is very difficult to find. We know that we have these ketone meters. A lot of people have these ketone meters-

Dr. Joseph Mercola:

That's easy.

Brad Marshall:

But those are really just measuring beta-hydroxybutyrate.

Dr. Joseph Mercola:

Yes.

Brad Marshall:

And like we said, the problem with that is it doesn't tell you – Just beta-hydroxybutyrate on its own. It doesn't tell you the ratio of acetoacetate to beta-hydroxybutyrate. It doesn't tell you the

ratio of NAD+ to NADH. And so yeah, I recently tried to get testing for those two things, but it was like $500. I think it was a Quest. But yeah, that's a simple thing and we can measure that. I think we can measure that pretty easily, and it doesn't take a huge amount of sample, as we were talking about before this call. And I think that's something that we could scale up pretty quickly.

Dr. Joseph Mercola:

Yeah, I think if we offer the test, we have to do the due diligence and see how we can get the samples inexpensively to the lab, but we're thinking of a good process for it. So, just to follow up on the beta-hydroxybutyrate, again, the higher the number, the better. If you can get your ketones to 5, well that would be great, but you better make sure that your acetoacetate is much higher, otherwise that could be highly problematic and it almost means nothing by itself. It almost means nothing by itself without knowing the other side of that redox pair because BHB, beta-hydroxybutyrate, is not necessarily good to have high levels of. You relatively want lower levels that are reflective of an optimal redox state. In other words, where you have a lot of NAD. No one would argue that. NAD is the gold standard with respect to having an ideal metabolic state. I don't think anyone who studies this area would disagree with that. And if you have a high NAD, that means you have relatively low BHB. And you can't have it the other way around, it doesn't work that way.

Brad Marshall:

Right. Yes, yes. I 100% agree that the gold standard should be that we have a high NAD+ to NADH ratio, really both in the cytoplasm and in the-

Dr. Joseph Mercola:

Mitochondria.

Brad Marshall:

And in the mitochondria. And that also comes – Well, and that's another thing that's hard to measure is pyruvate.

Dr. Joseph Mercola:

Yeah.

Brad Marshall:

It's easy to get lactate measured but-

Dr. Joseph Mercola:

Easy, easy. Not really cheap, but the meter's a few hundred dollars and the strips aren't cheap, but you can do it. You can do it at home.

Brad Marshall:

Right, you can do it. The pyruvate-

Dr. Joseph Mercola:

[inaudible 01:08:48] of your home.

Brad Marshall:

Pyruvate is another one.

Dr. Joseph Mercola:

You're not going to measure pyruvate at home. That ain't happening.

Brad Marshall:

Yeah, very expensive. And so those two tests, I think if you can have those two tests reasonably affordable.

Dr. Joseph Mercola:

Yeah, so the pyruvate and lactate redox pair, they really reflect the redox status of the cytoplasm, whereas the acetoacetate and the beta-hydroxybutyrate are the mitochondria. And why is that important to know?

Brad Marshall:

So, you have very different things. In the mitochondria, you want to have high NAD+ because that's where your metabolism is happening, and that is going to tell you how fast your metabolic rate's going to go, et cetera. Whereas in the cytoplasm, remember, that's where those desaturase reactions are taking place, and that's where lactate is being produced. And so, you also want to make sure – because if you have high NADH in the cytoplasm, that's when you start oxidizing your linoleic acid, that's when you start converting stearic acid to oleic acid, and that's when you start creating those oxidized LAMs (linoleic acid metabolites), the 5-HETE and the 12-HETE, when cytoplasmic NADH is high. And so, you want to know what's happening in both places, and it's complicated. There's interplay back and forth between both of them. And if the mitochondria is really overwhelmed and is spitting out tons of reactive oxygen species, then the cytoplasm can also get oxidized. So, you really want to know both.

Dr. Joseph Mercola:

Okay. So, that's the value of that. And you highlighted an important point that I hadn't considered, integrated into the explanation, and that is when you have high NADH, essentially a reduced state in your cytoplasm, you're going to activate the SCD-1 enzyme that reduces linoleic

acid. It lowers it, which superficially feels like a good thing, but it is like the worst because it's taking your linoleic acid right out of the fatty acid tissue or the stores, and it's oxidizing it.

Because linoleic acid by itself is relatively inert. It can get oxidized, but it's not that bad. It's the oxidized metabolic byproducts, the breakdown products that's the destruction. That's where most all the damage comes from and that's what you're catalyzing when you have this reductive stress in the cytoplasm and you have lower linoleic acid that you measure on a test. That's like, "Oh, that's a great thing." No, it could be the worst thing that could possibly happen to you if you have reductive stress. And you don't know if you have reductive stress in [inaudible 01:11:41] we just talked about.

Brad Marshall:

Yeah, absolutely. And I'll make one caveat to that, which is if you're eating food out of a restaurant deep fryer, then now you're getting pre-oxidized linoleic acid. So, that's another place that you can get oxidized linoleic acid.

Dr. Joseph Mercola:

Which is common in America, but the people watching this are smart enough to know to avoid most fried foods-

Brad Marshall:

We hope that is the case.

Dr. Joseph Mercola:

So, you can have the highest quality linoleic acid, the absolute highest quality virgin, pure linoleic acid, pristine, and it still happens. It doesn't matter. There's no difference between that and fried food.

Brad Marshall:

Yeah.

Dr. Joseph Mercola:

There just isn't. It's the same thing.

Brad Marshall:

You're absolutely right, though, that I believe once we've consumed the linoleic acid, once it's part of our tissues, you don't want to oxidize it. And to prevent oxidizing linoleic acid, you want to stay out of reductive stress and you don't want to – Yeah, there's other-

Dr. Joseph Mercola:

And there's other excretion rates for linoleic acid. You can let it leak out very slowly and have a good liver function, and it will attach to a glucose molecule and you'll excrete it in your urine, which is the best way, and then it's not oxidized.

Brad Marshall:

That's true.

Dr. Joseph Mercola:

Yeah. It's a slow process and you're not going to get rid of a lot. So that's why you have to really limit this process you just described because if it comes out quickly, you're toast. You're going to have severe damage that's going to cause some type of disease, typically the big ones — obesity, diabetes, cancer, heart disease.

Brad Marshall:

Yeah. Yep. Absolutely.

Dr. Joseph Mercola:

Yeah. So, that's a big one. So, I think you did a magnificent job of doing that. Now, one of the – is there anything you wanted to add to that?

Brad Marshall:

Yeah, so I'm trying not to go too far into the weeds. We can talk a about-

Dr. Joseph Mercola:

Yeah, don't go into the weeds because we're not discussing this with an audience of molecular biologists.

Brad Marshall:

Right. We've already gone pretty far into the weeds about reductive stress. What I would say is that the other thing to think about is this becomes a – and you can see this in a lot of rodent models, it has a momentum to it. So, when you desaturate a lot of your body fat and you have this, what ultimately winds up is that pattern that I described, you wind up with a lot of this oleic acid and a lot of this palmitoleic acid, it becomes part of that feedback loop that can kind of keep you stuck. And it does it in a lot of different ways.

The oleic acid is – The [inaudible 01:14:25] group has done a really good job of showing this, but you can see in a lot of studies, in mouse or rat feeding studies, they'll put them on these low-fat diets and they'll stay pretty lean, and then they'll put some of them on this high-fat diet. These diets are made in a certain way to purposely make them fat. And it'll fatten them up, and then they'll switch them back onto the original control diet. And the rats that were on the control

diet the whole time, stay lean, but the ones that were fattened and then you switch them back onto the control diet, they never become as lean as the mice that were on the low-fat diet the whole time.

And so, something is creating this momentum that once the mice are transformed into this alternative metabolism, they kind of get stuck there. And I believe that body fat composition is one of the major flywheels that's keeping people stuck. Even so, sometimes people will do what they can to fix their diet and it's not working and they get stuck there. And I think that's one of the main challenges that we need to work on, is once you're in that state, how do we put the fat composition back?

Dr. Joseph Mercola:

What you identified was likely a really good strategy that we kind of skipped over, but you did mention it once or twice, because we were focused on reductive stress. But the other component is the ostensibly paradoxical realization that reducing branched-chain amino acids, which are typically thought to be highly useful for activating mTOR and building muscle mass, may not be as healthy as you think. And I think it's probably even for a different reason, although I think we're going to agree with the mechanism is collectively, is that by reducing branched-chain amino acids, I'm pretty confident it's going to be correlated with some other negative amino acids, which are really not good in excess. That would be methionine, cysteine and tryptophan. And each one of those amino acids are negatively correlated with longevity. So, in other words, if you have high amounts of those, at least in relation to your other amino acids you consume, it's going to be a problem. And the branched chains themselves are problematic.

So, what you did was you went on a low branched-chain protein, and that really means you don't have a lot of meat. You can have some, but it has to be low. But you have a lot of connective tissue or collagen or gelatin, which is high in primarily three amino acids, glycine, proline, hydroxyproline. And those are highly – especially the glycine. But they're just absolutely magnificent. I think it's to lower those amino acids, but it's maybe more, I believe, of increasing the connective tissue, which is missing in almost everyone watching this. And that is, folks, I think, one of the biggest take-homes. And we did talk a lot about it, but I want you to discuss it now because it is absolutely imperative. And yes, you can take a collagen or something, but you need almost a third of your diet as connective tissue, ideally a third. And if you're taking 10 grams and you're eating 150 grams of protein, yeah, it's better than zero, but it's still not going to solve the problem. So, take it from there.

Brad Marshall:

Yeah. So, my favorite paper on this topic, it was pretty recent. I think it's 2018 or 2020. What they showed is that the glycine itself – So, it's kind of what you mentioned with the linoleic acid, is that the body attaches a glucose to it and then you can urinate it out. And so, it's hard for the body to get rid of fat-soluble things. And the way that we do it is we attach something that's big and water-soluble like glucose to the linoleic acid, and then it becomes soluble in the bloodstream and we can eliminate it in the urine. Well, it turns out that we do that with glycine, which like you say, is the main component of collagen and connective tissue. And that glycine

goes into your muscle tissues and the body attaches that glycine to unburnt fuel in your mitochondria. This is-

Dr. Joseph Mercola:

Wait. What is the unburnt fuel? I don't remember hearing this before.

Brad Marshall:

Right. What we're talking about is things like acetyl groups and things like butyl groups. And so, when we talk about reductive stress, we're talking about a buildup of NADH, but we're also talking about a buildup of acetyl groups, and that's the Acetyl-CoA. And we talked about acetylation. And so, the glycine, if you have extra acetyl groups in your skeletal muscle, the skeletal muscle will take in that glycine, attach the Acetyl-CoA to it, and you eliminate it in your urine. And this happens to a bunch of different – they call it acylglycines. [They] get eliminated in the urine, and these come out of your skeletal muscle and they're the unburnt fats, they're the unburnt fuels that have essentially built up in your mitochondria.

Dr. Joseph Mercola:

Wow. It's a detox agent?

Brad Marshall:

Well, it's reducing reductive stress, right?

Dr. Joseph Mercola:

Yeah.

Brad Marshall:

If we think about reductive stress as being a buildup of unburnt fuel, the glycine is being used directly to eliminate the reductive stress essentially. And what's interesting about that paper is what they showed is that for some reason – So, it was reported in 1969 [that] obese humans have high levels of circulating branched-chain amino acids and low levels of circulating glycine. And in this paper that came out in 2018 or 2020, they showed that if they restricted branched-chain amino acids to the animals, their levels of glycine would increase, and that the animals would release more of these acylglycines in their urine, essentially. And they showed it was reducing those acylglycines in the skeletal muscle, and they were able to burn their metabolism more efficiently.

And so, I think that there does really seem to be some connection between branched-chain amino acids, glycine and reductive stress. Now, I will say that I don't think that branched-chain amino acids are bad for everyone. I think that-

Dr. Joseph Mercola:

There's a time and place for everything, because they can help in building muscle, there's no question.

Brad Marshall:

Well, they can, and they're actually very thermogenic if you can burn them efficiently. But what happens is – my overriding theory about metabolic syndrome and obesity is that it's not necessarily a disease state per se, but it's an alternative metabolic state. And Dr. Mercola, you've heard me talk about this idea of torpor or the idea that many mammals hibernate. They have this ability to tune down their metabolism. And you see a lot of the same changes in hibernating animals as you see in humans with metabolic syndrome. And so, to me, they're very parallel, if they're not exactly the same, they're parallel processes.

And so anyway, if you're healthy and your metabolism is running well, I suspect that branched-chain amino acids are very good for you, and you can eat plenty of muscle meats and be fine. I still think you should balance it with connective tissues-

Dr. Joseph Mercola:

Well, I would disagree. If you're not balancing it with connective tissue, you're not going to be fine. It's biologically impossible-

Brad Marshall:

Right. I think you should balance it with connective tissue.

Dr. Joseph Mercola:

Yeah. You can't. You've got to have it. You got to have it.

Brad Marshall:

Right. But if you're in a state of metabolic syndrome, you probably are not good at breaking down those branched-chain amino acids. And in that case, you might want to restrict those branched-chain amino acids more severely.

Dr. Joseph Mercola:

Yeah, which is the majority of the population. The majority.

Brad Marshall:

Right.

Dr. Joseph Mercola:

The vast majority.

Brad Marshall:

Exactly.

Dr. Joseph Mercola:

Yeah. So, almost everyone watching this. Not everyone, but most everyone.

Brad Marshall:

Right. Yeah.

Dr. Joseph Mercola:

Now, I have never heard of that acylglycine, and I don't think you've mentioned [it] in any of our previous conversations, which were many. This is not widely known. You know it because you're a voracious reader of the literature, but do you know anyone who's talking about this? I've never heard [of] it.

Brad Marshall:

No, not really.

Dr. Joseph Mercola:

Yeah. This is like-

Brad Marshall:

To me, it's a keystone paper, but a lot of these keystone papers no one cares about.

Dr. Joseph Mercola:

Yeah, I know. Yeah. See, they stick out like a sore thumb. And I'm the same way when I read it, I see it and other people just dismiss it. But you follow this and it's a really important mechanism. I never knew that. It's another reason – It doesn't change my – I love glycine, we've been talking about it for many years now, and you could take it as a supplement. And interestingly, when Ray Peat started advocating it, he actually discouraged people to use the powder, because at the time he was saying that, it was true, because of the manufacturing methods weren't as good. They're better now, so it's actually okay. But ideally, you do want to get it from whole food.

And there's different ways to do it. I think bone broth is the best if you can make it yourself, and you can use the pressure cooker, like an Instant Pot, that can do that. And if you have healthy bones, you can make it in four hours. If you don't have healthy bones, like a conventional CAFO (concentrated animal feeding operation) beef bones, you can do it, but in two hours. But it's amazing. But you want to get joint bones. You don't want to just get a marrow bone with no joints. The connective tissue is in the joints. That's where it's at.

Brad Marshall:

Yeah. Well, I think there is also collagen in the actual bone structure that breaks down if you cook it long enough.

Dr. Joseph Mercola:

You want that extra bone structure, the surrounding ligaments and tendons and connective-

Brad Marshall:

Oh, absolutely.

Dr. Joseph Mercola:

Yeah. Because it's difficult to get the collagen out of the bone. It's just cemented in there. You can get it out, pressure cook it for hours. Some people cook bone broth for three days, and it's absolutely unnecessary, folks. You only have to cook for four hours in a pressure cover. If you're cooking it for three days, you're doing something wrong. You're wasting a lot of energy. There's no need to do that. A lot of time.

Brad Marshall:

Yeah. I get the beef tendon at the local Asian market. You can buy beef tendon and you simmer that for about four hours, and it's delightful.

Dr. Joseph Mercola:

Really? So, does it actually form a gel when you put it in the fridge?

Brad Marshall:

Well, they're big. They're probably 6 inches long and it's a full on tendon. And so, of course, it's like rubber when you first get it out, but if you slow-cook it for maybe four to six hours, it becomes soft. They serve this at a – If you go to pho, a Vietnamese recipe, you get a pho-

Dr. Joseph Mercola:

Wow. And how do you-

Brad Marshall:

-it'll say "sliced beef and tendon," and it's just pieces of the slow-cooked tendon. It's really good.

Dr. Joseph Mercola:

Well, you're a chef. So, how do you prepare this?

Brad Marshall:

I literally just put it. I don't even pressure cook it. I just put it on a pot on the stove and just cover it. I've got a Dutch oven and I salt it, and I just simmer it for about, say, four to six hours. It's perfectly ready to go.

Dr. Joseph Mercola:

Yeah, but do you cut it up? Do you put salt on it? Seasoning?

Brad Marshall:

Yeah, I do that, cut. I do it pretty simply. I usually just do salt. I do salt, and I thin-slice it. The texture is like, I don't know, it's not as firm as meat, but it has a chew to it.

Dr. Joseph Mercola:

You have to chew it. You don't just swallow.

Brad Marshall:

Yeah, you have to chew it. If you cook it longer, it'll get to where it's almost just dissolving. But I like it to where it still has some chew to it. Yeah.

Dr. Joseph Mercola:

And that's almost 100% connective tissue. So, if you've got 20 grams of beef tendon, you're eating it, that's 20 grams of collagen. That's exactly what it is. There's no other structure in there but collagen.

Brad Marshall:

Yeah, I think it's just – yeah, absolutely.

Dr. Joseph Mercola:

So yeah, that's good stuff. I did not know about the beef tendon. That wasn't available. So, I'm going to start getting that.

Brad Marshall:

Yeah, it's really good.

Dr. Joseph Mercola:

Yeah. It's almost impossible to overdose on connective tissue. No one eats it because who wants to eat connective tissue? I want to eat the meat, but that's crazy inverse of what healthy choices are.

Brad Marshall:

Right. And I make pig's feet and stuff like that too, but for most people, that's probably a bridge too far. But I feel the beef tendon is, it's one that most people would-

Dr. Joseph Mercola:

And it's a big volume, so you can get [a] substantial amount of collagen that way. Especially if you get a bunch of them, you could cook them up and store them for a while.

Brad Marshall:

Oh, yeah. Each one of them is probably, I don't know, 4 ounces or something.

Dr. Joseph Mercola:

Okay, that's perfect.

Brad Marshall:

It's quite a bit.

Dr. Joseph Mercola:

Yeah, 4 ounces would be, gosh, that's 120 grams. That's a two-day supply. Not many people need more than 60 grams of collagen. In fact, you could probably make an argument [that] it's a three-day supply.

Brad Marshall:

Yeah.

Dr. Joseph Mercola:

40 grams of collagen is a lot of collagen.

Brad Marshall:

Right. Well, it's got water-

Dr. Joseph Mercola:

Hardly anyone eats that much. Hardly anyone.

Brad Marshall:

It does have water content too, so I don't know quite what the water content is. So, it might only be-

Dr. Joseph Mercola:

Okay, it might be-

Brad Marshall:

It's going to be less. It's probably going to be maybe 50% collagen, 50% water, I would think.

Dr. Joseph Mercola:

So, that was off by 50%, but still, it's a lot of collagen.

Brad Marshall:

But still, it's a lot of collagen, yeah.

Dr. Joseph Mercola:

Yeah, which is what you want. There's one take home from this. What you want to do is definitely eat more collagen. This is one of the healthiest foods on the planet. It's just amazing. It's just absolutely amazing. And interesting, we can share for the public, that I was able to catalyze, offer you a position, or you actually suggested, and I said, "Yeah, that sounds good." You want to go into research, and you're getting rid of your hog business, and you're selling it to another friend of ours, which is Ashley Armstrong.

Brad Marshall:

That's right.

Dr. Joseph Mercola:

Yeah. So, she's absolutely delighted about that too, because her passion is just food production, just passionate about it.

Brad Marshall:

Right. She's very excited. And I've worked to build this business, but like I say, I just have too much on my plate. I'm itching to get back in the lab.

Dr. Joseph Mercola:

Aside from beef tendon, right?

Brad Marshall:

Aside from beef tendon. Yeah. So, I'm itching to get back in the lab and get that going. So, I was pleased to meet Ashley, and she was excited to take that on. And so, it's a nice pairing that you've-

Dr. Joseph Mercola:

Yeah, it's all worked out. It's really good. Because Ashley and I, and you're a consultant for this process too, we have a noble goal, which is essentially to destroy the industrial agriculture system, by the end of the [inaudible 01:29:28]. And I am beyond confident that we're going to do it. We have a plan. We know how to do this, and we have lots of protection around us that's going to allow us to do this, because there's going to be a lot of resistance. And that's a big industry that we're turning over. So, it's going to be fun. It's going to be fun to watch it. And it will be delightful. It will be delightful.

Brad Marshall:

Yeah. I couldn't be more excited to be part of it.

Dr. Joseph Mercola:

Yeah. It's a noble mission, so that we can create healthy food for you and make it available. Because the sad reality is for many years now, the food available to you has been progressively decreasing to the point, even though no matter how committed you are, no matter how wealthy you are, it is becoming almost impossible to find healthy food. You've got to know the ins and outs, and we're going to turn that around. We're going to make it easy and less expensive. And it's going to be more expensive than what you're currently doing because they reduced the price of food to extraordinarily low levels that in no way, shape or form could ever support healthy food production.

The price of most food is so low, and the quality is proportionately just as low, that you cannot survive on it. You just can't. It's dangerous to eat that food. It's beyond dangerous. So, you're going to sacrifice your life. And you can see this most clearly with what they've done with the pet food industry. That's going up too. There is no commercial pet food, almost no commercial, absolutes are very rarely correct, but there's almost no commercial pet food that is healthy. They're all bad.

Brad Marshall:

Yeah.

Dr. Joseph Mercola:

Yeah. It's really bad news. And as a result, pets are dying. Literally 50%, they live 50% less. And many of them die painful, suffering deaths, and their owners may spend tens of thousands of dollars to try to rescue them when all they had to do is give them the right food. And it's possible to do. Not commercially, you could create it yourself by getting real food, but just avoiding the commercial is the best thing you can do.

Brad Marshall:

Yeah. Agreed.

Dr. Joseph Mercola:

Yeah. It's good stuff.

Brad Marshall:

Good stuff. It's a tough world out there, and it's the food system. I've dealt with the FDA for probably five or six years in my shop, and they're-

Dr. Joseph Mercola:

Bad news. Bad news.

Brad Marshall:

They're a [tough] nut to crack, but we can do it.

Dr. Joseph Mercola:

Before we leave, there's one supplement. You don't have a lot of supplements in your company, but you do have one.

Brad Marshall:

I've got a couple. Yeah. My favorite, the best one-

Dr. Joseph Mercola:

I want you to talk about the SEA. The SEA.

Brad Marshall:

Yeah. Did you get yours, by the way?

Dr. Joseph Mercola:

I got mine yesterday. Yeah. I was really intrigued with it. It's stearic ethanolamine?

Brad Marshall:

Stearoylethanolamide.

Dr. Joseph Mercola:

Yeah.

Brad Marshall:

And so, what that is, this is a natural compound that your body makes. And it makes it from stearic acid, and it's made in your adipose tissues. And so, the-

Dr. Joseph Mercola:

Which is good. Stearic acid is good, folks. It's not bad. Don't let anyone tell you that it's bad.

Brad Marshall:

Right. And so, your blood levels of stearoylethanolamide, at least this is true in mice and we assume that the same is true in humans, are reflective of the stearic acid levels of your adipose tissues. And like I was saying, as you progress towards metabolic syndrome, diabetes, obesity, heart disease, stearic acid levels drop. And what is also seems to be true in the literature is that over the past hundred years, the average stearic acid levels of the average human being have also dropped. Because if you go back and look, 1943 was the first time that adipose tissue composition in humans was reported. And that paper says that humans had 8% stearic acid. If you look in that 1962 paper that I mentioned, where they went around the world and looked at people from Nigeria, I believe that paper, they were also reporting 6% to 8% stearic acid.

If you look at a paper now, people's stearic acid level is 3.2% or three point – 3.5% maybe. And so, as you said, people say something like, "Well, 95% of people have some level of insulin resistance." Well, they probably do. And that is coincident with this nationwide or worldwide drop in stearic acid levels. And that probably is, like I say, induced by reductive stress. And that reductive stress is driving forward those desaturase enzymes. And so, all of our stearic acid has been converted to oleic acid. But those fats are used as signaling molecules in our body. And that's what the SEA is. And if you look, we have a cannabinoid system and there's one called an AEA, which is arachidonoyl ethanolamide. And so, this is made from arachidonic acid, which is made from linoleic acid. And so, when AEA gets high, it triggers your cannabinoid system, your endocannabinoid system.

And of course, people know if you have too much cannabinoids, you can get the munchies. And so, this AEA is very tightly involved in appetite regulation, but also in metabolic rate through a variety of mechanisms. And the SEA, when it's high, it actually helps the enzyme to break down these endocannabinoids. And it helps to regulate your cannabinoid system. And like I was saying, as stearic acid levels drop, oleic acid levels drop. And OEA (ethanolamide oleoylethanolamide), the other one that's made from oleic acid actually inhibits – or actually, I think I have that wrong. I think it's the oleic acid itself that prevents the enzyme from breaking down the other endocannabinoids, the AEA.

And so, you have this kind of dynamic balance between the SEA and these other endocannabinoids over control of appetite regulation and metabolic control. There are studies in rodent models where when they gave them SEA, it reduced SCD-1 levels in their liver, which is the other desaturase we talked about, delta-9 desaturase. It massively decreases their appetite. If people are in – It's good to eat and have calories, but at the same time, you see animals going into torpor, become hypermetabolic. And people complain that they never feel satisfied and nothing turns their appetite, and that can be through this altered balance of these

endocannabinoids. And so, I've released the SEA about a year ago, and to me, just when I started taking it, I saw an increase in body temperature, suggesting that-

Dr. Joseph Mercola:

It's a good thing.

Brad Marshall:

-that my metabolic rate was up. I definitely had that loose feeling of hunger. You're thinking about food all the time, I think, was suppressed by the SEA. And there's a lot of people who have reported good success over on r/SaturatedFat with it. It seems to be really beneficial. So, that is the number one thing that I'm offering.

Dr. Joseph Mercola:

And what dose do you take?

Brad Marshall:

I've been taking 300 milligrams twice a day.

Dr. Joseph Mercola:

Oh, twice a day. Okay.

Brad Marshall:

Yeah. I usually take it with meals. I don't know if you have to take it with meals. I guess time will tell.

Dr. Joseph Mercola:

Yeah, you don't know. But it might make sense because it's really the type of food that would make perfect sense. So, it seems it would be targeted for someone who is metabolically inflexible and having challenges and has this activation of the SCD-1 enzyme to convert the stearic acid to oleic acid, and really suck out the linoleic acid and convert it to toxic byproducts. So, it's a good thing. If you're metabolically healthy, you probably don't need it or wouldn't hurt in any way because it's only useful.

Brad Marshall:

Yeah. It wouldn't hurt, but like I say, it seems like all of us probably have decreased circulating-

Dr. Joseph Mercola:

That's not all. It's mostly 95%.

Brad Marshall:

Right. 95% of us have-

Dr. Joseph Mercola:

It's probably closer to 96%.

Brad Marshall:

- decreased stearic acid levels from what we did a hundred years ago.

Dr. Joseph Mercola:

Yeah. And the numbers, you can estimate pretty accurately because it was from NHANES (National Health and Nutrition Examination Survey) data that was published in 2018. It wasn't published, but that's the data they extracted. That's six years ago, and the number then was 93.1%. There's no way it went down. It went up. So, it can't be less than 93%. It is probably closer to 96%, maybe even approaching 97%, which is ridiculous, but that's the reality.

Brad Marshall:

Yeah, I agree. Couldn't agree more.

Dr. Joseph Mercola:

Yeah. All right. There we go. All right, so how do they find this SEA? Where's your website?

Brad Marshall:

Oh, sure. Yeah. So, you can find me, the SEA is at fireinabottle.net/shop. My blog is at Fire In A Bottle. You can find all my past writings there. In the last year or so, I've been focusing more on my YouTube channel.

Dr. Joseph Mercola:

Yes, very good.

Brad Marshall:

Just go to YouTube.

Dr. Joseph Mercola:

And type in "Fire In A Bottle"?

Brad Marshall:

Type in “Fire In A Bottle.” You watched “How to Fatten A Mammal,” I think.

Dr. Joseph Mercola:

Oh, yeah. If you really want to go deep into this, you’ve got hours and hours of Brad going deep and much deeper than he did today and more complex with the molecular biology, and it’s really fascinating. I strongly recommend it.

Brad Marshall:

Yeah. So, the Fire In A Bottle [in] YouTube, you can go down all kinds of rabbit holes. We talk about, well, all kinds of things. “How to Fatten A Mammal” is a good jumping off place. I’m trying to think. There’s a lot of good ones. “The History of Body Fat Composition” is also one of my favorites because that really goes into this pattern that I talked about with the drop in the stearic acid and the increase in the oleic acid and the drop in the linoleic acid levels. I have all the studies, you can see exactly where I got this. I didn’t just make it up. So, all those videos, I back up with real studies. You’ll see the examples.

The Reddit group, r/SaturatedFat, that’s a great place to follow my stuff. That’s a really smart community there. There’s a ton of resources. People that have been following me, they understand the science. It’s a really good resource. I’m also on Twitter at FireInABottle. The new diet is called the Emergence Diet, by the way. And I will be having a website at emergencediet.com. So, go check that out. And yeah, those are the big ones.

I’m also on Instagram. I think it’s fire_inabottle, and I even have a TikTok that I think I have three videos on there, but if you’re a TikTok person, it’s either fireinabottle or fire_inabottle. I should remember my names, but I don’t.

Dr. Joseph Mercola:

Yeah, yeah. [Inaudible 01:41:02] things in life you should remember, but it seems you’ve got all the social media bases covered.

Brad Marshall:

Well, I try. I try. I keep up much more on Twitter and on Reddit than I do on the others, but I should be more active on social media.

Dr. Joseph Mercola:

No.

Brad Marshall:

It’s overwhelming.

Dr. Joseph Mercola:

Don’t shoot on yourself, please. All right, well, thanks for all you do and I’m looking forward to our collaboration. And now, most people are going to probably benefit from listening to this a few times. But if you do, you’ll have it and you can explain to your friends and relatives, and they’ll think you’re really smart, because it’s a topic virtually no one that you know understands. I can assure you with a high degree of confidence. As I said, I really only know three people personally who know it well. I’m not saying they’re the only three out there, but I think a good percentage of you could listen to this a few times and you’ll understand it. You can explain it to someone. That’s how you’ll know you’ll be able to understand it, when you can explain it to someone you know or love. Good.

Brad Marshall:

Yep.

Dr. Joseph Mercola:

All right. Well, thanks for all you do and keep up the good work.

Brad Marshall:

Yeah, thanks for having me on the show.

Dr. Joseph Mercola:

All right.