Welcome to the Huberman Lab podcast where we discuss science and science-based tools for everyday life. I'm Andrew Huberman and I'm a professor of neurobiology and ophthalmology at Stanford School of Medicine. Today my guest is Dr. Lane Norton. Dr. Norton is one of the foremost experts in protein metabolism, fat loss, and nutrition. He did his degrees in biochemistry and nutritional sciences and has considered one of the world experts in understanding how we extract energy from our food and how exercise and what we eat combine to impact things like body composition and overall health. Today we discuss an enormous number of topics under the umbrella of nutrition and fitness, including for instance, what is energy balance? That is, how do we actually extract energy from our food? We also discuss the somewhat controversial topic of artificial sweeteners, whether or not they are safe or not, they are an effective tool for weight loss, in particular for people suffering from obesity and different types of diabetes. We also talk about gut health, that is the gut microbiome and how it's impacted by food and how it can actually impact the metabolism of the foods that we eat. We also discuss fasting or so-called intermittent fasting or time restricted feeding, what it does and what it does not do in terms of how effective it is for weight loss and perhaps even for health and longevity. We also talk about protein and define very clearly how much protein each and all of us need depending on our daily activities and life demands. We discuss the various types of diets that you probably heard about including ketogenic diets, vegan diets, vegetarian diets, and pure carnivore diets as well as more typical omnivore diets and how to make sure that you get all of the essential amino acids that are critical for healthy weight maintenance, weight loss or directed muscle gain. We also talk about supplements in particular, the supplements for which there is an immense amount of science pointing to their safety and efficacy for fitness and for overall body composition. What I'm sure will become clear to you as you hear Lane talk about each and every one of these topics is that he has an incredible ability to both understand the mechanistic science but also the real world applications of the various discoveries that are made in particular papers and in particular in the randomized controlled trials that is when a given scientific hypothesis has been raised, he's extremely good at understanding why it was raised but also at evaluating whether or not it works in the real world which is what I believe most everybody out there is concerned with. I think this is one of the things that really distinguishes him from the other voices in the nutritional landscape. I assure you that by the end of today's discussion you will have a much clearer understanding about what the science says about nutrition, about fitness, and about how different diets and fitness programs combine to achieve the results that you want. Before we begin I'd like to emphasize that this podcast is separate from my teaching and research roles at Stanford. It is however part of my desire and effort to bring zero cost to consumer information about science and science related tools to the general public. And now for my discussion with Dr. Lane Norton. Thank you so much for being here. This is a long time coming and I have to say I'm really excited because I've seen you in the social media sphere. I've also listened to a number of your other podcasts. And as a fellow PhD scientist, I feel a great kinship with you. I know you have tremendous experience in fitness and nutrition and a number of areas. We also got a lot of questions from our audience. And I'm really looking forward to talking with you today. Yeah, I'm excited too. Like you said, it's been something we've been talking about for a long time. So I was glad we were able to make it happen. Yeah, it need. And I think some of the audience has requested a debate or a battle and I can tell you right now. It's not going to happen. Actually, one of the things that brought Lane and I together in conversation online and then via text, etc. was the fact that I love to be corrected. And that's what happened. I did a post about artificial sweeteners, which we will talk about a little bit later in the episode. And Lane pointed out some areas of the study that I had missed or maybe misunderstood. And I revised my opinions. And I think it's wonderful and other studies have come out since then. So hopefully our conversation will serve as a message of how science and actionable science can can be perceived and that it doesn't always have to be a battle. But hey, if we get into it, we get into it. It won't get physical because we know you would win. In any case, I'd like to start with something that's rather basic and yet can be pretty complex. And that's this issue of energy balance and energy utilization. I think most people have heard of a calorie. I'm assuming that most people don't actually know what that is in terms of how it works, what it represents. And so maybe you could just explain for people what happens when we eat food of any kind. And how is that actually converted into energy as a way of framing up the discussion around weight loss, weight maintenance, weight gain and body composition. So a great question. And like you said, this is one of those things where people use the term calories and calories out. And they say, well, that's way too simplistic. And I'm like, if you look at what actually makes up calories and calories out, it's actually very complicated. Right. So let's deal with the what you mentioned first, what is a calorie? Because I think a lot of people don't quite understand this. So a calorie just refers to a unit of energy of heat specifically. And so what does that have to do with food? What does that have to do with like what we digest and eat? Really what you're talking about is the potential chemical energy that is in the bonds of the macronutrients of food. Right. And by digesting, assimilating and metabolizing those nutrients, we're able to create energy. And the in product of that mostly is ATP. A denizen triphosphate, which is your body's energy currency. So to understand ATP, just try to think about if you're trying to power these various reactions in your body. And we're talking about tens of thousands of enzymes that require ATP. You know, it doesn't make sense that you would have to create a bunch of micro explosions. Right. You want something that can transfer high energy phosphates to power these reactions to give up essentially its energy to power something that might otherwise be unfavorable. So a lot of metabolism is simply creating ATP, which the end of the line of that I'm going to kind of work backwards is what's called oxidative respiration. So that happens to the mitochondria. Everybody's heard mitochondria powerhouse of the cell. And that is done through essentially creating a hydrogen ion gradient across the mitochondria, which powers the production of ATP by converting. Free phosphate plus ATP to ATP. Now the way that hydrogen ion grading is created is through creating hydrogen hydrogen ions that can be donated through the crebs cycle. Now the crebs cycle is linked to glycolysis. So if we talk about carbohydrate metabolism, carbohydrates, basically other than fructose get converted into glucose, which can go into glycolysis. And you can produce some ATP through glycolysis. And then it boils down to pyruvate, then the Cedal CoA, which goes to the crebs cycle produces a lot more ATP's from that. If you talk about protein, protein's a little bit different because protein gets converted to amino acids, which can be used for muscle protein synthesis or protein synthesis and other tissues. But it also can be converted through glycineogenesis to glucose. And there also are some ketogenic amino acids as well. And so you can have a few different ways to get to the crebs cycle, either being through a Cedal CoA or through glucose going through the glycolysis to pyruvate. Then you have fatty acids, which are able to create energy through what's called beta oxidation, where essentially you're taking these fatty acids and you're lopping them off two carbons at a time to produce the Cedal CoA, which again can go into the crebs cycle. It produces hydrodion that can then power the production of ATP. So that's kind of like at the cellular level of how this stuff works. But stepping back and taking it back out, like what does that have to do with weight loss or weight gain, right? Well, when you think about the balance of energy and versus energy out, sounds very simple. But let's look at what actually makes up energy and versus energy out. First of all, you've got to realize that the energy inside of the equation is more difficult to track than people think, right? So one, food labels, which we like to think is being, you know, like from upon high, can have up to a 20% error in them. Really? Oh yeah. So 100 calorie is something this is 100 calories per serving. It could what's actually in there could be 80 or 120. Right. Exactly. So that's one aspect of it. The second aspect is those what's called your energy, but then there's also metabolizable energy. So if you have food stuff with say a lot of insoluble fiber, typically insoluble fiber is not really digestible. And so you could have, you know, quite a bit of carbohydrates, you know. But if you can't extract the energy from it, and typically this is because insoluble fiber from like plant material, the carbohydrate or even some of the protein is bound up in the plant structure, which makes it inaccessible to digestive enzymes. And so this is what like adds both to your school stool or whatnot. But again, reduces the metabolizable energy in there. And there's some evidence that based on people's individual gut microbiome. That some people may actually be better at extracting energy out of fiber compared to other people. So just starting off right there. Okay. There's, there's quite a bit of play in the energy inside of things. Now, one of the things people will say is, well, see, that's why you shouldn't worry about tracking calories, because, you know, if the food labels can be 20% off. And what I'll say is, okay, that's a, that's, I understand where you're coming from. But typically if it's off, it's going to be consistently off. And if you're consistent with how you track it, eventually you'll be able to know kind of what you're taking in. And it's kind of like saying, well, don't worry about tracking, you know, if you're, I like to use financial examples. You know, we know that to save money or you have to earn more money than you spend. Well, you can't exactly know how much money you're earning at a time, you know, because there's inflation. And then there's, if you have investments, those can be, you know, different interest rates and whatnot. It's okay. But you're, you know, if you have a budget, you have a reasonable idea of what it's going to be, you know, and you make, you make certain assumptions. But you can relatively guess. Yeah, that's a good example. Right. So now let's look at the energy outside of the equation, which is actually way more complicated. Right. And so your energy out is a few different buckets. The first one and the biggest one is your resting metabolic rate. So your RMR. And that for most people is anywhere from 50 to 70% of your total daily energy expenditure. Now, people use the term metabolic rate and energy expenditure kind of interchangeably, but they're not the same thing. So your total daily energy expenditure is the summation of all the energy you expend in a day, walking upstairs, exercise if you do it, fidgeting. Yeah. Plus your resting metabolic rate. Right. So resting metabolic rate is a big part of that, but it's not the only thing. So that's usually about 50 to 70% and sedentary people will be on the higher end of that. So it'll be a bigger proportion. Whereas people who are more active, it'll be a little bit lower. Not because their metabolic rate is lower, but because they're expanding a greater percentage of the calories from physical activity. Then you have something called the thermic effective food, which is a relatively small percentage of your total daily energy expenditure. It's about five to 10%. And very difficult to measure and usually what researchers do when they're kind of looking at this stuff as they just kind of make an assumption about it. They use a constant. But that's about five to 10% of your daily energy expenditure. And that refers to the amount of energy it takes to extract the energy out of food. So think about your body kind of like a car, right? You don't just have gas in your tank and it spontaneously starts up, right? Like you have to have a battery. So you put in energy so you can get the energy out of the petrol that you have in your car. Similar with food, you can't just eat food. And then you know, it just appears in your cells and you start doing stuff. It has to be systematically broken down and put into forms that can actually produce energy. And so you have to put some energy in to achieve that. And a lot of times people will say something like, well, not all calories are created equal. That's not true because calories just a unit of measurement, right? That would be like saying not all seconds on a clock or create an equal. Yes, they are. All sources of calories may have differential effects on energy expenditure and appetite. So if we look at something like fat, for example, the TEF of fat is about 0 to 3%. Meaning if you get 100 calories from fat, your net will be about 97 to 100. So the process of breaking down that fat, essentially subtracts some of the calories away because you used it in creating energy by breaking those chemical bonds to create ATP. Correct. Correct. So you have like, for example, some enzymes that require ATP to run these processes. Now fat is actually the easiest thing to convert into energy. Then you have carbohydrate, which has a TEF of like 5 to 10%. So you eat 100 calories from carbohydrate. And obviously like the fiber content makes a big difference on this. But as you eat 100 calories, you'll net 90 to 95 protein is about a 20 to 30% TEF. So if you 100 calories from protein, you're only netting 70 to 80. Now you're still net, you know, people say, well, you can't eat too much protein. Well, you know, people will ask, well, can protein be stored as fat? The carbon is from protein. It's unlikely it's going to wind up an adipose tissue. But if you're eating a lot of protein, overall as part of a lot of calories, it has to be oxidized and it can provide a calorie cushion for other things to be stored in fat. But protein itself does provide, you know, a net positive for calories, but less so than carbohydrate or fat. And tends to be more satiating. So again, when people talk about, you know, are all calories created equal. Yes, but all sources of calories may have differential effects on energy expenditure appetite. So that's the TEF bucket and the BMR bucket. Then we go to physical activity and physical activity is essentially two parts. There's exercise, which is kind of your purposeful movements like you go for a walk, you do a training session, you know, whatever, any purposeful activity. And then you have what's called neat, which is non exercise activity thermogenesis, which I think is actually really cool. It's fascinating. Yeah, it is. So it's I was actually hanging out with somebody last night and I was noticing them. They they were fidgeting their feet and their fingers. And I said, you know, have you always like been pretty lean and they're like, yeah, I never really had a problem maintaining lean this. And when you look at the obese resistant phenotype, people think they have high BMR or, you know, they exercise a lot and really what it seems to be as neat. They tend to, if they overeat, they just spontaneously increased their physical activity. Now people get neat confused. I've heard people say, well, I'm going to go out for a walk to get my need up. That's not neat. Neat is not something you can consciously modify what you're doing there. If it's purposeful, it's exercise. So for example, if I'm talking if I'm waving around my hands, if I'm tapping my feet, if I'm whatever, that's neat. But, you know, trying to like get yourself, well, I'm just going to tap my foot more. Well, now if I'm consciously having to do this, then my focus, I mean, you know how the brain works. Very hard to do. You know, you don't really do two things at watch. You kind of switch quickly between tasks. Right. Can I quickly ask was the person that you're referring to our friend Ben Bruno? No, no, he is fidgety too. Amazing online fitness channel. He's a freakishly strong individual. Yeah. And I can't remember whether or not Ben, you're a fidgeter or not, but anyway, I'll have to go check and we'll measure your fidgeting about non-exercise induced thermogenesis. Neat, my understanding of the old papers on this old being I guess back to the mid 90s is that the calorie burn from meat is actually pretty significant. We're not talking about a hundred calories or 200 calories per day. We're talking about in some cases, hundreds of thousands, hundreds to maybe even close to a thousand calories per day. Could you elaborate on that? Yeah, so there was actually a really classic study. I think from I want to say it's from Levine in 1995. It was a metabolic ward study. And hopefully I don't butcher the study because I'm trying to, you know, pull it out of my brain. I don't expect you to have public. Although I must say you have a quite extensive PubMed ID grab bag in there. So I try to bring the receipts. I try to bring the receipts. We can put we will put a link to the study in the show no captions. So people can prove it if they like. So I believe they had people overeat. I think it was by like a thousand calories a day. I think for six weeks. And I mean, this is a metabolic ward. So they are this is very tightly controlled. It's as tight as you get. And what was interesting is of course on average people gained weight and gained fat mass. But some people gained more than expected. And there was one person in particular who only gained like just over half a kilo. Right. They should have gained like. I think it was something like three to four kilos was was predicted. And what they found is this end of individual just spontaneously increased their physical activity. But he didn't purposely do it. It just happened. And I mean, you know anecdotally, I've seen people who are again, you know, very lean. Even eat a meal sit down and start sweating. You know, and be very fidgety. There was a natural bodybuilder back in the day named Jim Cordova. And this guy was just very lean all the time. And he was exactly that phenotype. You know, he would walk up a fly to stairs and all of a sudden he's sweating. Sit down. Need a meal. He's sweating. You know, he just he's a furnace just expending energy. And what's very interesting about neat is that seems to be the most modifiable. I mean exercise is very modifiable because you can be intentional with that. But of, you know, BMR T E F and neat. Neat seems to be far more modifiable. So even a bodyweight reduction of 10%. They've observed a decrease in neat of almost 500 calories a day for a 10% reduction in bodyweight. Now, you also do get a decline in BMR when you lose weight one because you're just in a smaller body now. And so it takes less energy to look a moat. But also there's what's called metabolic adaptation, which is a further reduction in your BMR than expected from the loss of body mass. And that's on average usually around like 15%. But it does seem to be there's new evidence coming out on the metabolic adaptation from BMR. And it seems to be a little bit kind of in the transition phases. So if you if you start a diet within the first few weeks, you will have a reduction in BMR that then kind of just after any further reduction is mostly from the amount of body mass you lose. And then if you like, for example, finish a diet and move your calories to maintenance within a few weeks, BMR kind of starts to come back up. There is still a small reduction, but I used to be somebody who thought the BMR, you know, the metabolic adaptation was a big reason why people stopped losing weight or plateaued. And now I think it's much more to do with neat. Interesting. And you said that it can't be conscious because of that will distract us from other activities. I don't know if you've had chance to look at this study and I'll send it to you. Maybe I'd be fun to do a kind of an online journal club about this at some point soon. But there's a study that came out of University of Houston recently having people do now. This is a long period of time for hours a day of basically a soliast push up, which basically a heal raise, kind of a seated calf raise with one foot, not weighted. And then they looked at a bunch of things about glucose metabolism and glucose clearance and insulin levels. And they didn't conclude that people burned a ton of calories, but what they concluded was that blood sugar regulation improved greatly. And I think, you know, there was a lot of excitement about this at some level, but based on everything you're telling me, this fits perfectly with what's known about neat. So this sort of fell somewhere in between with in between excuse me, sort of deliberate exercise and spontaneous movement. I guess they've tried to make that spontaneous movement a little bit more conscious. Well, what I'll tell people is if you're worried about neat, one thing you can do, like these watches, for example, people like, oh, what told me I burned this many calories. They are not accurate for energy expenditure. I mean, it is like there was a meta analysis in 2018. I want to say between a 28 and 93% overestimation of energy expenditure by these watches. So for those of you listening, we're not going to name the brand, but fitness trackers, so risk-worn fitness track. And this is across the board. So like depending on the brand, it could be more or less, but they all overestimated the amount of calories you've run from exercise. So this is actually a great example where people go, well, calories in calories out doesn't work for me because I ate in the calorie deficit. I didn't lose weight. When I talk to them, usually it's, they went to an online calculator. It's one of a few things. They went to an online calculator, put in their information. It's sped out some calories to eat, and they ate that and didn't lose weight. And it's like, well, what do you think is more likely that you're defying the laws of, you know, conservation of energy or that you might have not gotten the right number for you. The measurement tool was off. The next thing is a lot of people weigh varies sporadically, and I'll tell people like if you're going to make an intentional weight loss a goal. And again, this can be different for different people, but typically I tell people weigh in first thing in the morning, or I have to go to the bathroom, do it every day, and take the average of that for the week. And then compare that to the next week's average. Can I ask one, sorry to interrupt, but one quick question about that when you say go to the bathroom, not to get too detailed here for unnecessarily, but are you talking about your nation and emptying your battles? Ideally, because you get a big meal the night before. Yeah, got it. So wake up, use the bathroom in all forms that you're ready. And then get on the scale, take that measurement, average that across the week, and then maybe every Monday you take that value and see progress. And the reason I recommend doing that is if you're just kind of sporadically weighing in as somebody who weighs themselves pretty, pretty regularly, I mean, my weight will fluctuate, you know, five, six pounds and not seemingly changing much, you know, and that's just, you know, those short term changes are fluid. So I've had it before where week to week, my average didn't change, but between the lowest weigh in from a previous week and the highest weigh in might have been like eight pounds, right? So if you're somebody who just randomly is weighing in and you're eating in a calorie deficit, and you just weigh in one day where you just whatever reason holding some more fluid, then you see this isn't working. When in reality, your average might be dropping, so that's one of the reasons and actually believe it or not, weight fluctuations are actually identified as a major reason why people get discouraged from weight loss. It kind of stops the buy-in, you know, when they have a fluctuation up. So that's one of the reasons, one of the reasons early on that low carb diets tend to work really well is because people lose a lot of water weight really quickly and they get that buy-in, right? So all of this is working. Yeah, we can return to that in a little bit because I have theories as to how that, you know, when people eat less carbohydrate, they scrape more water and they'll see, you know, for the first time they'll see some definition in their absence, you know, oh my god, the diets are amazing. And the fluid loss does hold that promise. I think fluid loss can do some other things that might make people literally feel lighter, although we have some negative effects. I do have a one quick question and I do want to return to neat in a moment, but when you say the caloric burn as a consequence of exercise, I want to ask about the caloric burn during that exercise. So for instance, somebody's on the treadmill and they'll see, okay, they burn, you know, 400 calories. Actually, I think this is a month where a number of prominent podcasters like Bert Kreischer, Tom Segura, Joe Rogan, others are doing, they call it sober October, but in addition to avoiding alcohol, they're burning 500 calories per day during the exercise. They're measuring it. A lot of people do this. They think they take track of whether, excuse me, take stock of how many calories they burned. My understanding is that if that particular form of exercise is a muscle building form of exercise that at some point later, there might be an increase in muscle. If you did it, everything right, do everything right, and then you will burn more energy as a consequence of adding that tissue. So I think that's a long process, as you know, and we will discuss. But I have heard about this post-exercise induced increase in oxidative metabolism. I'm probably not using the right language in here. So if I were to go out, for instance, and do some sprints, run hard for a minute, jog for a minute, run hard for a minute, do that 10 times over. Let's assume I burn 400 calories during that exercise about. But my understanding is that in the hours that follow, my basal metabolic rate will have increased. Is that true, and is it significant enough to care about? So I answered both those questions. Yes, there does seem to be a small increase in metabolic rate, and no, it does not appear to be enough to actually make a difference. So when they look at, and again, this is where I tell people, I think I have a good perspective on this because my undergraduate degree is a biochemistry degree. So I was very into mechanisms. It was like, oh, if we just do this, and this, we'll get this, right? And then I did nutrition as a graduate degree, and then my advisor was so great because you could do something over here, and he could tell you how would affect vitamin D metabolism over here. This is Don Laman. Yeah, Don Laman. So, you know, he would always kind of say, yeah, but what's the outcome going to be, right? So this is actually one of the things I changed my mind on was I used to be very much, well, I think, you know, high intensity interval training is probably better because you get this post exercise energy burn, which they do see in some of these studies. But in the kind of meta analyses and like more tightly controlled studies where they equate work between high intensity intervals and moderate or low intensity cardio, so equating work, they don't see differences in the loss of body fat. And so to me, if I'm looking at that's the example of a mechanism, which is, okay, we're seeing this small increase in basal metabolic rate. That should lead to increased loss of body fat, but again, remember, you're capturing a snapshot in time, right? But we don't see a difference in the loss of body fat. So what may be happening, and again, I'm just speculating, but a way to explain it could be, you might have an increase, and then you might actually have a decrease that tends to just kind of wash it out. I see. And I have to imagine some forms of exercise, this would be highly individual, but we'll spike appetite more than others. So for instance, if I go out for a 45 minute jog, or which I do a 45 to 60 minute hike or jog once a week, I just make it a point to do that, or rock or something like that, throwing away best and hike. After that, I find I'm very thirsty, I want to hydrate, but I'm not that hungry. That's true of most all cardiovascular exercise for me. But after I weight train about 60 to 90 minutes later, I want to eat the refrigerator. And so obviously, calories in, calories out dictates that that will play an important role as to whether or not I gain or lose weight, et cetera. So is it safe to say that the specific form of exercise that people choose needs to be taken in consideration of calories in calories out, so how much is burned during the exercise? Also, how much that exercise tends to stimulate appetite? I don't know whether or not people explore this in the rigorous studies. And whether or not that form of exercise actually increases lean muscle mass or not. So now we've taken exercise and split it into a number of different dimensions, but this is what you are so masterful at is really parsing how the different components work individually and together. So if you would just expand on that, I'd love to know what you're thinking. Yeah, so this is actually really fascinating thing. So first thing I want to, I want to just go back to talking about, like for example, Burton, Tom and Joe, we're going to do 500 calories a day on whatever. So those apparatuses don't measure those things effectively either, right, just like these watches. But the one thing I will say is if you are, like for example, if I do two hours of resistance training, typically this will say I burned about a thousand calories. That's a lot of resistance. My weight workouts are like, are warm up for 10 minutes and then one hour of work done. I just, I love to train. And you can recover from my recovery quotient is pretty low, so I've been training for 30 plus years and I found that if I do more than an hour of hard work in the gym, meaning resistance training, 75 minutes, maybe I'm okay, but past that, I have to take two, maybe even three days off before I train my nervous system just doesn't tolerate it well. I like, I limit it to an hour, you know, and part of that to remember is like I've kind of built up to that over a long period of time, right? So you couldn't just throw somebody in and start having them do two hours a day. It's not going to go well for them. I'd like to take a quick break and acknowledge one of our sponsors, Athletic Greens. Athletic Greens now called AG1 is a vitamin mineral probiotic drink that covers all of your foundational nutritional needs. I've been taking Athletic Greens since 2012, so I'm delighted that they're sponsoring the podcast. The reason I started taking Athletic Greens and the reason I still take Athletic Greens once or usually twice a day is that it gets to be the probiotics that I need for gut health. Our gut is very important. It's populated by gut microbiota that communicate with the brain, the immune system and basically all the biological systems of our body to strongly impact our immediate and long term health. And those probiotics and Athletic Greens are optimal and vital for microbiotic health. In addition, Athletic Greens contains a number of adaptogens, vitamins and minerals that make sure that all of my foundational nutritional needs are met. And it tastes great. If you'd like to try Athletic Greens, you can go to Athletic Greens.com slash Huberman. And they'll give you five free travel packs that make it really easy to mix up Athletic Greens while you're on the road and the car on the plane, etc. And they'll give you a year supply of vitamin D3 K2. Again, that's Athletic Greens.com slash Huberman to get the five free travel packs and the year supply of vitamin D3 K2. But I will say about the calorie trackers is so if I'm used to, okay, usually burn about a thousand calories according to this, it's not accurate. But if I go in tomorrow and I do 1300, it may not be accurate. I don't know what the exact number is, but I can be relatively confident that it's more than the previous session. And so in terms of comparison, it might be okay, like, you know, kind of within subject. And then the other thing I was kind of circling around on was if you're worried about neat, tracking your steps can be helpful because people's step counts can spontaneously decrease when they're not a fat lost diet. They don't even realize it. So, and that again, not a complete measure of neat, but what we've had some clients do with our team, myelin coaches is they'll say, okay, you're at 8,000 steps right now. We're not going to add any purposeful cardio, but whatever you need to do to maintain that 8,000 steps, do that. And sometimes they have to add, you know, 15, 20, 30 minutes of cardio because there's spontaneous activity that they're not even aware of goes down. That's a really excellent point. I've heard, you know, the 10,000 steps per day number was, we all heard that. And then I learned that 10,000 was just kind of thrown out as an arbitrary number. So, like, 8 hour intermittent fasting thing, there's a story behind that. It's actually spoke to Souchin and it turns out that the graduate student in his lab that did that initial study, which was on mice, by the way, was limited to being in lab for about 8 hours by their significant other. So, the 8 hour feeding window is actually the consequence of this person's relationship. That is a really great point that people don't realize when they, a lot of people will try to copy, like, scientific studies. And I'll tell people, like, listen, scientific studies are so confined, you need to be very careful with how broadly you apply what's in there, right? Like, they're, they're a very big hammer is the kind of the way I look at it. Okay, they're not a scalpel, they're a big hammer. And I think a lot of times in terms of coaching, scientific studies will tell you what not to do rather than what to do, right? But getting back to your question about, like, exercise appetite. So, first off, I'm not really aware if there's evidence showing, like, differential effects of different forms of exercise on appetite. It's possible. But again, it also could be like a placebo effect, right? Because we, like, for example, you and I grew up in an era where the muscle magazines, it was like, well, as soon as you finish your workout, you can have your biggest meal of the day, right? And, you know, when I say placebo effect, I think people have the wrong idea of what the placebo effect is. They think that's just a feeling. Placebo effect can actually change your physiology. People don't, people don't realize this. There's research showing that a placebo where the power of suggestion is basically as powerful as some pharmaceuticals. And one of the, the great examples I like to use is actually there was a study we just covered in our research review on creatin where they did four groups, not supplement with creatin, told they weren't supplemented with creatin, not supplemented, told they were supplemented. So they were, supplemented, told they were. Basically, it just matters what they told them really. Oh, yeah, this is incredible. I have to get this study will so we can link to a colleague of mine at San Bernard. She's been on the podcast. I'd love to introduce you to you because I think he is really really rough. The former D1 athlete and then runs a lab at Stanford psychology is is Leah Crumb and she's and grew up in this, you know, very athletic obviously and very, very smart. And her laboratory focuses on these belief slash placebo effects where if you tell people all the horrible things that stress studio in terms of your memory and cognitive functioning, and then you give them a memory test, they perform well below baseline. You tell them that stress sharpens them in the short term and that adrenaline is this powerful molecule that can really tune up a number of memory systems memory improves and it's remarkable. And it's consistent and this and they've done this for any number of different things and these dollar Gs for instance, you know, incredible results. In any case, I'm so glad you're bringing this up. I take creatine monohydrate and have for years five grams a day. I don't know what's great and and it's great and I believe it's great. So is there a compound effect of believing it's great and it actually. So not not in this study, but so I think the thing to point out people will misinterpret that as creatin does it work and that's not what that says what it says is your beliefs about what it does are probably just as powerful as what it does. Right. So they actually did a study and I don't have the citation, but it was I think within the last 10 years where they told people they were putting them on anabolic steroids and wouldn't you know it they had better gains even though they weren't actually on anabolic steroids they had better gains than people that they didn't tell were animal steroids and that's like hard outcome strength, lean body mass, you know, those sorts of things. So when people say, well, I wouldn't fall for the placebo effect. It's like, you don't have to fall for it. If you believe it to be true. The power of belief is very, very powerful. And as a scientist, I wish sometimes I was ignorant so that I could subject myself to the placebo effect more often. Absolutely. So kind of getting back to that's just a possible explanation of maybe why, you know, and I'm the same way like I get down with a workout, I could resist a training session, I'm like, I'm ready to eat right now if you look at the literature overall on exercise and appetite, it's not always what you'd expect consistently it seems to show that exercise actually has an appetite suppressing effect. So people don't tend to compensate at least fully for the amount of movement they do. And there is some evidence that you've probably heard people say exercise a really poor weight loss tool, right? Like if you figure out how many calories you should be burning from it and you do that, you end up getting less weight loss than you then you would predict. And I'm not a fully member who is perfectly happy to eat less, but doesn't load exercise, but dislikes exercise. And they're of healthy weight. But I'm always encouraging them to exercise more. And so this is an ongoing battle in our in our sibling relationship. Well, one thing I would say is that exercise independent of anything that happens with your body weight, you will be healthier. So exercise is one of the only things that will actually improve your biomarkers of health without even losing weight. So there's like an improved insulin sensitivity, inflammation, all that stuff. So everybody out there looking for a hack to be healthier exercises the hack. And our mutual friend, Dr. Peter, I think has gone on record several times now saying that of all the things that one could take, and a man, et cetera, metformer of regardless of whether or not one takes those or doesn't take those that the positive effects on longevity by way of biomarkers from regular exercise is far outweighs all of those things combined. And those things don't necessarily work, but we're not going through them in detail now. But that exercises by far the best thing we can do for our health span and lifespan. Yeah, absolutely. I 100% agree. And when you're talking about weight loss, people miss the point of exercise, I think there's some work that came out from Herman Ponser as well that basically showed like, well, if you do 100 calories from exercise, you have a 28 calorie reduction in your basal metabolic rate in response to that. And it's kind of like this constrained energy expenditure model, right. But what I would say is, okay, well, there's still a net of 72, right. So it's still it's still okay. And the other thing is, I think the effects of exercise on weight loss are actually more due to what it does to appetite. If you look at people who lose weight and keep it off for a number of years, kind of outliers because most people don't keep it off for years, over 70% of them engage in regular exercise of people who do not keep weight loss, like maintain weight loss less than 30% exercise regularly. Now, that's just a correlation that doesn't necessarily prove causation, but there are some pretty compelling studies showing that exercise increases your sensitivity to satiety signals. So basically you can have the same satiety signals, but you're more sensitive to them when you exercise. There's actually a really classic study from the 1950s in Bengali workers where they looked at basically four different quadrants of activity. So you had sedentary, lightly active, moderately active, heavily active, basically based on their job choice. And they didn't have an intervention. They just wanted to track them and see how much, you know, how many calories did they actually eat. So it was like a J shape curve. So the sedentary actually ate more food than the lightly active or moderately active. But from lightly active to heavily active, they almost perfectly compensated how many calories they should be eating. So to me, that suggests when you become active, you can actually regulate your appetite appropriately or much more appropriately than if you're sedentary. Do you think this has to do with changes in the brain, brain centers that respond to satiety signals from the periphery and or do you think it has to do with changes in blood sugar regulation. What I was taught, and I don't know if this is still considered true, is that you know spikes in blood sugar will trigger desire to eat more, even though it's kind of exactly the opposite of what you need when you're a spike in blood sugar. And there's this kind of and we'll get into this when we talk about artificial sweeteners. This is the idea in mind. I think I adopted perhaps falsely that you eat something that sweet or that tastes really good and you are suddenly on the train of wanting to eat more. And I could imagine how exercise if it is increasing the satiety signals could be working in a number of different ways. I think it's a I think the effect is probably mostly at the brain level. You know, the effects on blood sugar. The research out there is not very compelling for blood sugar driving appetite. Now, if you become hypoglycemic, yes, you'll you'll get hungry, but it's a different kind of hunger than like your normal like I feel kind of empty and my stomach's growling. And those are they can go together, but usually like the hypoglycemic is like, I am hot. I feel like I'm going to pass out like you want to eat something not because your stomach's crawling, but because you know that you just need some fuel. It's like you're getting pulled under. Oh, yeah, absolutely. I've been there. I've been there when I've done longer fast something I don't do anymore and drank a lot of black coffee. And then I'm going to be in electrolyte effect there because coffee as you excrete sodium and other electrolytes. And then just feeling like I needed something this whole thing like I need something that's kind of desperation. I never want to be back here again. Hypoglycemia is very uncomfortable. So, you know, again, when they and then when they look at actual randomized control trials of implementing some exercise where they're pretty controlled environment, they typically see people if if anything, they eat less as opposed to eating more. Again, that's, you know, study report averages, right? And there's individual data points. So there are some people who at least anecdotally report that exercise makes them more hungry. That's completely valid. It's now it could be their beliefs around it. It could be a number of different things, but it's important to understand that there is individual variability. And I think one of the things that I've learned to appreciate more is not trying to separate psychology and physiology. we do this a lot. And it's like, well, I want to know the physiology. I don't care about the psychology of it. And now I'm kind of appreciating more psychology as physiology. You know, like with most things now, we have kind of the biopsychosocial model. And I'll give you an example of this. A lot of people get really caught up with appetite. And if we could just suppress people's appetite, that's part of it. But people don't just eat because they're hungry. They eat for a lot of different reasons. Social reasons, especially. So can you remember the last social event you ever went to that didn't have food? Right. If you look at dinner plates from the 1800s, what about this big? Now how big are dinner plates? The whole buffet. Right. Right. Yeah. If you, there's situational cues, right? You're staying down to watch TV. Grab some popcorn, grab some snack, whatever. I even see this with it, you know how one person will pick up their phone and then everyone picks up their phone. I think there's a similar effect with food. Yeah. And same thing, right? Like how many times have we either done it ourselves or have been experienced people saying, oh, you should have something. You should have it like alcohol, especially, right? Like people will, I was saying that was somebody last night. And I had a beer and they just had a water. And I'm like, I feel no need to try and convince them to do that with me, you know what I mean? But as humans, you know, we're kind of hurt animals. Like we don't want to be doing something out on isolation on our own. Now I'm, this is a very tenuous, I guess, belief of mine. But, you know, doing things alone in isolation, you know, during kind of, you know, ancestral times, that's going to sit off your alarm system, you know, because if you don't have other people, you can't protect yourself, right? So typically things were done together in groups. And I think that's a lot of the reason why we tend to be just tribal in nature about a lot of things, right? So the whole point to that is, you know, on the list of reasons why people eat, I mean, I've gotten the point where I think that hunger is actually not even the main reason people eat, you know, stress, lack of sleep, boredom, boredom, yeah, absolutely. So unless, you know, we can do something that addresses all those things, there's a line from a review paper, this review paper came out in 2011 by a researcher named McLean, and it's the best review paper I've ever read. It was called Biology's Response to Diating the Impetus for Weight Regain. And basically went through all the mechanisms of these adaptations that happened during fat lost diets and how biology's response is to try to drive you back to your previous. And I'm going to butcher the quote, but at the end of the study, he said, basically, the body's systems are comprehensive, redundant, and well focused on restoring depleted energy reserves. And any attempt or any kind of strategy for weight loss that doesn't attempt to address a broad spectrum of these things is going to fail. And so that's why when people say, well, just do low carb, you won't be hungry. You have it. People don't just eat because they're hungry. So I think really like trying to get outside the box and think about these things, and especially when you read some of the literature, I recently read a systematic review of successful weight loss maintainers, which I thought was really interesting. So they took people who had lost a significant amount of body weight and kept it off first, for I think it was three years. And they basically asked them questions and tried to identify commonalities. And there were some things that I expected, like cognitive restraint, self monitoring, exercise. And then one of the things they said that I found really fascinating was pretty ubiquitous between people. They said, I had to develop a new identity. So are you familiar with Ethan Supli? No. So Ethan is an actor. He's been like, remember the Titans and American History X. I certainly saw American History X. Yeah. So he was very large. Like he was like 550 pounds. And now he's like 230 and jacked. Like he was how? He was 550 pounds. Wow. And he has it. Whenever he puts up posts on his Instagram of him training, it'll say, I killed my clone today. And I asked him, like, is this what you're talking about? Like creating a new identity. And he said, this is exactly what I'm talking about because I had to kill who I was. Because there was no way I was going to be able to make long term changes if I just didn't become a new person. Because there's, I mean, an addicts talk about this, right? Like people who are alcoholics, they had to get new friends. They had to hang out at different places because their entire life had been set up around this lifestyle for alcohol. And I would actually argue that eating disorders or disorders eating patterns is much harder to break than other forms of addiction. And people have food addiction. Well, in some ways, bulimia and or XC are still addictions. You can't stop eating. Like your alcoholic, you can abstain from alcohol. If you become addicted to say cocaine, you can abstain from that. You can never abstain from food. And so now imagine telling a gambling addict, well, you've got to play this slot a couple of times a day, but no more. Like that's really challenging. So yeah, I just like all this stuff, it's so important to be comprehensive with how we treat these things. These are incredibly important points. And to my knowledge, I don't think anyone has really described it in a cohesive way the way that you're doing here is so important for people to understand this because obviously as a neuroscientist, I think the nervous system is creating our thoughts, our thoughts, our feelings, our related to psychology. And therefore, of course, our physiology and our psychology are one in the same. It's bi-directional. Now there's a lot of interest in brain body and particular gut brain access. And we can talk about that. But I really appreciate that you're spelling out how there are these different variables. Each one can account for a number of different things. Exercise clearly has a remarkably potent defect, both during the exercise in terms of caloric, where an overall health and biomarkers. And then this is wonderful to learn that it can increase the sensitivity to satiety signals. I think that makes, at least in my mind, places very high on the list of things that people should absolutely do, but that there are other factors too. And the identity piece is fascinating. It reminds me also, your story reminds me also of David Goggins, who is, you know, he talks about his former very overweight self almost as if it was a different person. And he uses language that I'm not going to use here. But I know, Matt David, no David a bit, and he's every bit as intense and driven as, and a remarkable human being as he appears to be online. He is that guy. But it does seem like he had to more or less kill off a former version of himself and continues to do that every day. And I think what you're point about the Southern fellow who does it through a similar process. The word today seems to really matter. It's not like you defeat this former version of yourself and then that person is buried and gone. You said, you know, I killed my clone today. And that's the way that David talks about it also. So this is a daily process. And I think this is not just a small detail in tying together all these things. I think that what you are describing is fundamental because we can pull on each one of these variables and talk about each one of them. But at the end of the day, we were cohesive whole as an individual. Sorry, you were about to say. That gets actually in one of my favorite topics, which is, you know, why do we have such a hard time with losing weight but more so keeping it off? Because of obese people, six out of every seven obese people will lose a significant amount of body weight in their life. So why do we still have an obesity problem? They don't keep it off. Why don't they keep it off? When you look at the research, basically what it suggests is because people think about, I am going to do a diet and I'm going to lose this weight and they do not give any thought to what happens afterwards. Right? It's like, think about it if you have some kind of chronic disease or a diabetic, right? You can't just take insulin once and that's it, right? You got to take it continuously otherwise you're going to have problems. If you do a diet and you lose, you know, 30 pounds, fantastic. But if you then just go back to all your old habits, you're going to go back to where you were if not more. You can't create a new version of yourself while dragging your old habits and behaviors behind you. So what I'll tell people is, because people say, well, I'm doing a cart of or diet or I'm doing this diet or that diet and I'll say, that's fine. Do you see yourself doing that for the rest of your life? And if the answer is yes, if you really believe that that's going to be sustainable for you and plenty of people, low carb, intermittent fasting, whatever, they say, felt easy. You know, I could do this forever. Great. What if you're going to lose weight, you have to invoke some form of restriction, whether it is a nutrient restriction, like low carb, low fat, a time restriction, intermittent fasting, any form of time restricted eating or calendar restriction, tracking macros, whatever. So you get you get to pick the form of restriction. So pick the form of restriction that feels the least restrictive to you as an individual and also do not assume that it will feel the same for everybody else because I made this mistake. Whereas like I track things. And so I allow myself to eat a variety of foods. I allow myself to eat some fun foods. But I track everything and I'm able to modify my body composition and be in good health doing that. Now, it doesn't feel hard for me. I had part of it. So I've just been doing it for so long. But other people, that's very stressful. They don't want to do this. Well, I'd rather just not eat for, you know, 16 hours. If that feels easy for them, do that because the one thing that there was a couple of men analysis on popular diets and basically what they showed was they were all equally terrible for long term weight loss. But when they stratified them by adherence and none of them were better for adherence overall. But when they stratified people just according from lowest adherence to best adherence, it was a linear effect on weight loss. So really what it says is, what is the diet that's going to be easiest for you to adhere to in the long term and you should probably do that. And people, again, this is where I step back and take the 10,000 foot view. Somebody will say, well, I'm going to do ketogenic because I want to increase my fat oxidation and I want to do this and they're talking about all these mechanisms and everything. And that's great. Can you do it for the rest of your life, right? Is this going to be something sustainable for you? And if the answer is no, you probably need to rethink what your approach is going to be. It's incredibly important message. Basically that. You know, if I could highlight, you know, if there was a version of highlight or bold face and underline in the podcast space, I would highlight both face and underline what you just said. And for those of you that heard it, listen to it twice and then go forward because it's absolutely key. I think it also explains a lot of the so-called controversy that exists out there. I think it also crosses over with the placebo effect. I almost want to say, pick the nutrition plan that you think you can stick to for a long period of time, ideally forever. And pick your placebo too because there is a lot of placebo woven into each and every one of these things, intermittent fasting, keto, probably even vegan versus omnivore versus carnivore. Well, they even talk about, you know, the diet honeymoon period, right? Where like you go into a diet and you're all fired up about it and like you're varied here and then what happens with every single diet without exception in research studies is once you get past a few months adherence just starts waiting. Does it go off? Here we are really talking about a form of relationship, you know? I'm not saying that to be tongue in cheek. Actually, we had a guest early on in the podcast, Dr. Carl Dyseroth, he's a psychiatrist and about engineer at Stanford, tremendously successful, last year award winner, etc. And he talked about love as a sort of an interesting aspect of our psychology where it's a story that you co-create with somebody but that you live into the future of that story. You know, when you pair up with somebody that we used to refer into romantic love, that there's this sort of mutual agreement to create this idea that you're going to live into. So it's not just about how you feel in the moment, it's also that you project into the future quite a lot. I'm seeing a lot of parallels with a highly functional and effective diet and I love it. I'm not setting this parallel up artificially. I'm setting up because I think that ultimately it was down to what you said earlier, which is that the brain and our decisions about what we are going to stick to are tremendously powerful. I think one thing I will say is like keep in mind, when you look at the research data, the meta-analyses on say time restricted eating versus dawn, when calories are equated, doesn't seem to be a difference in weight loss, fat loss, and most biomarkers of health. Same thing for low carb versus low fat. Few equate calories in protein. There was a meta-analysis done by Kevin Hall back in 2017 where they looked at the, and again, actual also body fat. Another important point was, I think there was 22 studies in this, but all of them provided food to the participants. That's important because that ensures that adherence can be much higher in those studies, whereas various free living studies sometimes you can see funky results. People are sneaking food or they're just not really eating the way that study would ideally have them eating. Unless the person is getting continuous support, studies where they have a dietitization and talk to people like every week tend to actually have pretty good adherence. But I mean, that's expensive to have done a study. And again, like what limits studies, money, money, and money, right? But the low carb versus low fat and protein and calories are equated basically no difference in fat loss. Now, some people get upset about this, but it's like what to me, that's like this is great because you get to pick the tool you want. That one tool, it doesn't seem to be that much better than another. So pick the one that works for you, right? Whenever lever you've got a pool, you've got a bunch of different options. Mentioned picking something you can stick to for a period of time, is there ever a case for someone saying, look, I like to eat low carb or even keto for six months and then switch to a more standard omnivore caloric maintenance type diet and then switch back. Is there any downside to doing that for sake of health or weight loss over time or weight maintenance over time? Because I realize not everyone is trying to lose weight. And I definitely want to talk about at some point how to eat to maintain weight. Because I think there are a significant fraction of people out there who are trying to do that. Is there anything, is there any downside to being a dabble or keto for a few months and then omnivore for a few months, etc? I think that's actually a great thing, especially to maybe find what you feel is easiest for you, right? But in terms of like as a strategy, I mean, I guess some people, this might get into dopamine, but like, oh, change and get something new and like, you feel a bit more positive about it. And do partner model. Yeah, exactly. So I don't think it's how I would usually set things up initially for somebody, but if somebody said, hey, I just like to have some variety and change it up. As long as they're still like, you know, their behaviors and they're doing portion control or whatever it is and they're able to sustain a calorie deficit or, you know, depending on whatever their goal is, I don't think there's really any downside to it. I do think the one thing to keep in mind is when you look at like going between extremes, so like low fat to low carb or or vice versa, there can be in that transition period, a little bit of weirdness for lack of better term. Like for example, if you've been on a ketogenic diet and all of a sudden you move to like a higher carb diet, you'll be like basically insulin resistant for just a short period of time. Is that going to cause any health problems, probably not in the long term, especially if you're still controlling calories, but just because your body has kind of like up regulated these systems, dealing most with mostly with fat and glucose production rather than glucose metabolism. So now if you start taking glucose or carbohydrate back in, like for example, you get somebody or glucose tolerance test after they've been on keto, they do pretty terribly at it, but that doesn't last that long about how long? A few weeks, I think that's important for people to know because I have a feeling during those first few weeks or the period of time when a lot of people will go running back to what they were doing previously, which is not to say that they shouldn't, but I've certainly done that. I've tried very low carbohydrate diet and I would have assumed, and now I know I'm completely wrong, but I assumed that I was so carbohydrate starved for so long that my insulin sensitivity, which is a good thing, by the way, folks, would have gone through the roof and I would be able to just sponge up every bit of glucose that I would have ingested through carbohydrate. So I did indeed switch over and I felt like a pretty terrible brain fog. I even got some jitters and I thought, what is this? My blood sugar was low before and now my blood sugar should be in more moderate territory, but based on what you just said, I'd upregulated the enzymes and systems in the body for fat metabolism on the keto diet and then switching over, there was basically a ramping up of the molecules involved in presumably in glycolysis. Transition period. Think about if you haven't weight trained before and you start weight training, you're going to feel pretty terrible, right? You're going to be sore and stiff and all that kind of stuff. But I will say you aren't necessarily wrong in what you said about being more insulin sensitive because it depends on how you measure insulin sensitivity. So if you measure with something like fasting but glucose or fasting insulin or even home IR, those tend to be pretty good on low carb. But then if you do an oral glucose tolerance test, it tends to be pretty bad. And so it depends on your specific measure, right? So I think that the idea that keto makes you glucose intolerant or insulin resistant, I think again, it's just a transition period. And I'm not too worried about it. But there is something important to keep in mind. And one of the reasons I get somebody who's to transition out of keto, typically if like I'm working with them or one of our coaches or working with them, we'll kind of instruct them to do it like slowly and kind of systematically over like a four to eight week period. That way hopefully, you know, they're not having that period of two weeks where they're like, oh man, why do I feel so terrible? Very important point. I want to go to the other end, literally and figuratively and talk about gut health. Because up until now and certainly what you did with that point. And certainly in the last few minutes, we've been talking a lot about sort of top down processes. You know that the brain, the psychology, placebo effects, but the very real aspects of those, not that I can imagine 2,000 calories as a thousand calories and somehow changed a lot of third-bond dynamics. Can't do that. You can sort of top down in integrating a lot of different ideas into weight loss maintenance and weight gain. But gut health, at least the more popular studies on gut health, have blown a lot of things out of the water. For instance, this idea that you could take obese mice and literally give them fecal transplants from lean mice. And yes, that sounds like what it sounds like. People transplants definitely inserted through the same end in which it comes out. And I point that out because a lot of people will ask me that they, you know, it was kind of scary to me. I thought, yes, this is not about ingesting feces. This is they literally do a transplant of feces from lean mice into obese mice and the obese mice get lean. And yes, this has been done in humans, limited number of studies and observed some pretty impressive effects on weight loss that I have to assume could be related to placebo effect. They might have told these obese people, hey, look, you're going to get lean through this fecal transplant from lean people. But more likely it had some effect on their core physiology. I don't know which aspects, although I can speculate which ones. And they became leaner. They lost weight. And that is in some sense miraculous when, especially given the important role of psychology and exercise and satiety signals, because I'm going to assume that they controlled for a number of those other variables, although no study is perfect. What are your thoughts about gut health as it relates to metabolism, energy utilization and balance? Yes. So the first thing I'll say is not a gut health expert, but I will, I feel relatively comfortable talking about it based on conversations I've had with people who are experts, one being Suzanne Devkota, who's, are you familiar with her? Well, she's sort of a phenom in this area from what I understand. So she was actually doing her masters when I was doing my PhD in layman's lab. So she was one of my lab mates for a fact. And you know, I, the other thing to say is even gut health experts and Suzanne will tell you this. They're like, you know, talked to me in 20 years. We just know so little. I think that's an overall thing that people don't understand is the scientific consensus moves very, very slow. And probably for good reason, because if we just flipped our scientific consensus based on one study, I mean, you, it would be, I think, I think, I think that's a good thing. A mess, right? So it's going to take time before you really understand the implications of the gut and what it means. So when it comes to weight loss, there probably is a role in there. I mean, we've seen that there's something going on. Now whether that's, is it something where a gut, back microbiome makeup that's more obese, resistant, perhaps it extracts less calories out of the food you eat, right? Or perhaps it's elevating BMR, although I think that that's probably somewhat unlikely. Do you think it could impact the way satiety signals are? So that's the brain again. So that's, we know that there's a link in the gut brain access. And so my suspicion is that it probably is working via appetite regulation. So that, I mean, if we look at, if we look at the most effective obesity treatments out there, which is like, somaglutide, I mean, you consistently see a, you know, 15%, you know, on average, loss of body weight, which is massive and people keep it off, that is a GLP1 mnemetic, which is a gut hormone. And it basically just is a very, very powerful appetite suppressant. Not, well, I guess I'm interrupting, but hopefully with a purpose. There's this really interesting study, and it's in mice admittedly, but a publishing at neuroscience journal recently. And the basically to take away is that like so many things in neuroscience, the GLP1 works in two parallel pathways. In the brain, it seems to impact neurons in the hypothalamus, the control satiety. So exactly what you're saying. And in the gut, it seems to create a, an activation of the mechanosensors in the gut. So the perception is that the gut is full, even or fuller. I should say not full, because I think people who take some of the glutei don't feel bloated and I don't know what they might, but that one feels as if their gut is actually fuller because these mechanosensors that sense stretch or sending signals to the brain, oh, I actually have some food. I'm not empty down there. Right. Anyway, I'm tickled by this result mostly because every time I hear about a drug or a molecule having effect, we think it has an effect at one location, but it's kind of interesting that especially for something like appetite regulation that it would be impacting body and brain and parallel. Anyway, forgive me. That's okay. You could tell I'm, I'm, it's really excited about this. And here you are telling neuroscientists me that a lot perhaps circles back to these brain mechanisms of satiety. Yeah. I mean, I think that, and especially looking at the research on leptin, you know, like, we used to think, okay, metabolism is mostly like liver-based and then, you know, there's, there's, you know, metabolism, the adipocyte and skeletal muscle, but none of this stuff exists in isolation. There's so much crosstalk between these pathways. And that's, you know, when we get into mechanisms, the one of things, I love mechanisms, but one of the things I tell people is keep in mind that when you're dealing with an outcome, right? When I say outcome-based, we're talking about physical outcomes like weight loss, fat loss, changes in blood markers, whatever, though that is the summation of thousands of different mechanisms. So sure, sometimes you can affect a mechanistic pathway and you get just kind of straight down the line outcome, but not always. You know, whenever you make a treatment or, you know, kind of anything into the system, it's like throwing a pebble in a lake, right? It creates ripples and we don't always know what those are going to be, right? And that's why, I mean, we've seen, you know, certain drugs, what works on this pathway and then they list off all the side effects and you go, well, how would it create that many side effects? Because nothing, for the most part, they don't just work in one place. There's multitude of places it works. And to your point about stomach luteide and the effects on mechanosensors, it's probably while a lot of people report actually kind of like low-grade nausea when they're using stomach luteide because of that. Because if you're, you know, that feeling is usually not like a real comfortable feeling, but I mean, it will get you to not eat. So I think there's absolutely likely a connection, but we haven't fully elucidated how that works and we think about how complicated the gut is. I think I heard something like there's more cells in our microbiome by far than there are in our body. So we're actually more in terms of a cell per cell level. We're actually more bacteria than we are eukaryote, right? There's Justin Sondinberg who's one of the world experts on microbiome. He's in the lab upstairs for minutes, Danford. And he has this idea, it's just an idea that because we are indeed more bacteria than we are cells, the question is who's the host and who's the passenger. You know, like maybe we are just, maybe they are exploiting us to take them around and interact because they interact and grow on one another. And so this idea, this freaks people out. Lex Friedman will love this, that maybe human beings are just actually the vehicles for the microbiome and not the other way around. Anyway, kind of a scary thought. Do you do anything specifically to support your gut microbiome? Are you a probiotic guy or a fermented foods guy or a fiber guy? So again, I'm going to kind of go straight down the line from whatever from Suzanne and other experts. So if you want to improve gut health, one of the biggest levers, the three biggest levers you can pull is not eating too many calories, exercising. There is a connection between exercise and the gut and fiber. So we, it is of the things we know dietary fiber seems to positively impact the gut because it is a what's called a prebiotic. So your gut microbiota can take especially soluble fiber, although there's actually some evidence at least in mice that they might be able to use some insoluble fiber as well. I think Suzanne was doing a study looking at hemicelulos and actually seeing that some like specific forms of microbiota flourish with hemicelulos, suggesting that they may actually be getting some kind of fuel out of it, which is really interesting. Again, in mice, so you know, just huge caveat. So your gut microbiome can produce these short chain fatty acids from by fermenting this soluble fiber. And there's quite a bit of evidence that these volatile fatty acids, which can be then actually reabsorbed into the liver, that they have some positive effects. Like for example, butarate, when they've done butarate supplementation, they've actually seen positive effects on insulin sensitivity. So what we seem to understand is that more diversity seems to be better. Fiber seems to be positive. Prebiotics seem to work much better than probiotics supplemented prebiotics. So the problem with most of the probiotics is they're typically not concentrated enough to actually colonize. And even if you do colonize, what happens is like, let's say you colonize some microbiota that you didn't really have much of. If you're not fueling it with the appropriate fiber, it's not going to stay anyway because it's essentially going to starve. So the research seems to really clearly suggest that eating in a fiber, which is again, a prebiotic, that that is a better way to get a healthier gut per se than probiotic. What fiber sources do you use? And I think I'm going to, I realize there's a huge array of choices out there, but people will want to have some ideas as to how they could perhaps mimic what you're doing. Yeah. And I would just say diversity, right? So there's various evidence from various different fiber sources for which investibles, obviously, grains, some whole grains, some cereals, and then various other sources. So this is one of the things where we don't really have a good idea if this one source of fiber is better than another source of fiber. We just know that fiber overall is pretty good. And one thing I'll tell people is like, if you want a longevity hack, I mean, fiber is kind of the longevity hack. If you look at some of these cohort studies, there was actually a recent really large metanalysis of over a million subjects. And basically what it showed was that for every 10 gram increase in fiber, there was a 10% reduction in the risk of mortality. And that extended specifically also to cardiovascular disease and cancer. So one of the things I'll tell people when they get like really into, you know, whether it's in a fasting or, you know, with all these other things, that's great. That's great. Are you eating like over 50, 60 grams of fiber a day? And I just, because it's specialized 50, 60 grams. So if I already like a, like a, like a, let's just say a quarter plate of broccoli. And the broccoli is in stack to the ceiling. The broccoli is just reasonably stacked on there. Approximately how many grams of fiber is that? If it's like, like two cups of broccoli, there's a lot. Yeah, so if you like 200 grams of broccoli per se would probably be like five, six grams of fiber. And I need to get how much per day? Well, I would say, I would typically what the recommended dose is is 15 grams per thousand calories intake. Because if you're eating, you know, low calories, it's difficult to get enough fiber in. But based on, and again, these are cohort studies. So, but you can't do 20 year long randomized human control trials. Additionally, there doesn't really appear to be a top end, at least for the benefits of fiber. It probably boils down to like how much you can tolerate without feeling uncomfortable, right? Because if you're eating like a ton of fiber, I mean, at some point, it's not going to be very comfortable. Exercise becomes uncomfortable or hazardous. Yeah. And I actually have kind of touching on that because I think it is important. You know, a lot of people have kind of, in the carnivore community said, well, you don't need fiber. You poop just fine without it. And I always say, well, pooping is the last reason to have fiber. Like, yes, it does help. It does seem to make elimination easier. You can, you know, do it more frequently as bulk to stool. But that's not why you should eat fiber. Why you should eat fiber is because of the effects of mortality. And you know, some of the pushback will be, well, this is healthy user bias. And what I'll say is, meaning healthy people do this and therefore it's probably more fiber and therefore. And I mean, yeah, there's something to that. But if it was just healthy user bias, typically you would see some disagreement between the studies. And a great example of that is like red meat. So not every study shows red meat has an association with cancer and mortality. There's differences depending on the population use, depending on what they define as high red meat, low red meat, whether it's processed, unprocessed. But I have not found a study on fiber and cardiovascular disease and cancer and mortality where it did not show improvements from higher fiber. So to me, that suggests that that effect is real. And so again, you know, as much fiber as you can get in comfortably, I would try to do it because it seems to have some really powerful effects and is good for the gut microbiome. The other thing that may be a consideration for the microbiome is there's some evidence that saturated fat may not be great for the microbiome that it reduces the prevalence of some of the more positive strain to bacteria. And that appears to be not so much from the saturated fat itself, but from the bile in products that combine with saturated fat seems to have a negative effect on some of these more healthier forms of gut microbiota. But again, this is really difficult because we don't even know necessarily yet which species of gut microbiota are positive or negative. And that's, I mean, this gets into some of these studies where they may call it dysbiosis. Sounds scary, but dysbiosis just means that the gut changed, right? It doesn't necessarily, I mean, it doesn't tell you anything qualitative about whether the change was better good. And so these are just things I think we need to keep in mind when we talk about this stuff. This stuff is still very much in its infancy. But in terms of the big lever levers, I mean, it pretty much fits with what we know about a healthy lifestyle. Exercise, don't eat too much, consume a good amount of fiber from different sources. Fantastic. Fantastic because it fits with what I like to think of as kind of the center of mass of evidence, right? And I'm starting to get some window into what your process is around selection of studies and no one study being holy, but when you look at, as you mentioned, all the studies on fiber having a positive effect to some degree or another, it's pretty hard to refute that there isn't something really interesting there. I want to tell people it's like, you know, one study, I mean, sometimes I'll change my opinion based on a single study when it's really well done and very powerful. But usually like one study is just going to move me just a little bit, right? And maybe if another one comes out, move me a little bit more, right? And then like very slowly, I'm going to get some, I'm going to get some, I'm going to be in my experience with LDL cholesterol. This is something I changed my mind on a while back when I was younger, like circa 2005, getting into grad school. Kind of the prevailing thought was, well, it's not so much the LDL. It's the ratio of LDL to HDL. That's what matters. And probably about five years ago, and I was, I was pretty strong about that opinion. And then five years ago, looking at these Mendelian randomization studies, I kind of went, I can't hold this position anymore. What is your revised position on LDL? So if you look at the research, HDL is important because it's a marker of metabolic health. If you have high HDL, it suggests that you are metabolically quite healthy. You very rarely will you have high HDL in like high CRP, which is inflammatory marker, or dysregulated blood glucose, almost exclusively people who have high HDL will have good biomarkers of metabolic health. But if you take drugs that raise HDL, it doesn't reduce your risk quite of ask of disease. In Mendelian randomization studies, which Mendelian randomization basically uses natural randomization. So some people are, in the case of HDL, naturally higher secreters or naturally lower secreters of HDL. And we talked about how you can't really do a 20 year human randomized control trial. And when you're trying to examine something like heart disease, I mean, that is a lifetime exposure issue. It's very unlikely that you're going to pick out differences between treatments in two years or even five years. I mean, people don't develop typically, don't develop heart disease until they're in their, you know, 50s, 60s and 70s. What Mendelian randomization allows is to say, okay, we have these people who naturally secrete more or less so we can stratify those and look at what is their risk. So if you look at people who are low secreters of HDL versus high secreters of HDL with holding some of the other key variables consistent like LDL, you don't see an effect on heart disease really of LDL of HDL got it. Okay. But when you look at LDL and you look at the lifetime exposure to LDL, it is like a linear effect on heart disease. And we know that it's actually not so much LDL, but it's more apolipoprotein B, but that tends to track with LDL just in general. And if you look at the mechanism, I mean, we know that LDL can penetrate the endothelium. So there's the mechanism is present. If we look at the epidemiology, it supports that it's an independent risk factor. And then again, these Mendelian randomization studies where we can kind of look at people's exposure over a lifetime. And then we see that linear kind of dose dependent effect. To me, that was convincing enough to change my mind on that particular topic. And then if you look at some of the Framingham data, look at high, if you like stratify, like high HDL versus low HDL, both groups looking at high LDL and low LDL. So if you have high HDL, low LDL, you will still be lower risk factor than somebody who has high HDL and high LDL. Right? So the ratio does matter. So the ratio does matter. The same thing with inflammation, if you look at people who are low inflammation, low LDL, they'll have a lower risk than people who are low inflammation, high LDL. So again, that was kind of sufficient for me to change my mind. But it took, it was like not just one study came out. It was, okay, then there was another study and then another study and then another study. And at a certain point, I go, okay, well, now I either have to change my mind or I'm basically just going to be cognitively dissonant and say, nope, I don't believe all that. And so I think that's one of the things to keep in mind people will say, are you saying this is a bad study? Very rarely why I call something a bad study. Because data is just data. But the issue becomes how it is presented and how broadly it's applied in the mainstream media or by people on, you know, fitness influencers. And what I'll do is try to step in and say, okay, let's consider X, Y and Z as well. And then it's not a bad study, but let's just be careful about how broadly we imply the interpretation. Yeah, well, and I think you are in a very unique and important position to be able to place things into their proper context because of this, relax, but better word, holistic view of how the psychology, placebo effects also core physiology relate to one another and so on. In fact, I think that you're training as a biochemist and then training as a nutrition with somebody who, on layman who was pushing you to focus on outcomes. I think that's a beautiful capture of the continuum at which one can look at something. Because for those of you who don't know out there, you know, a lot of laboratory studies on mice and humans, for instance, in the realm of biochemistry or in vitro studies, you'll see a change in some molecule can be quite traumatic. And then the assumption is, oh, you just take, you take the drug that will change that molecule in a particular direction and then you'll get the effect you want at the whole organism level. The person will lose weight, the person will gain muscle, the animal will not have Alzheimer's et cetera, but it just doesn't work that way because of the redundancy and this interplay. Well, a great example of that is so my research was actually in rodents, all my studies on protein metabolism and and leucine in particular is what we were studying. Well, we know if you give leucine and increase muscle protein synthesis, but we also know if you supplement with leucine, people don't get more muscular. I was about to say that all you have to do is supplement with leucine. Right, right, right. And so how is that possible where, you know, muscle building is not just protein synthesis. It's also the balance between synthesis and degradation. So, um, and degradation just happens to be very, very difficult to measure, but a great example. And again, one of the cool things about my PhD was actually changed the way I ate, which I think is interesting. So before I had been like, I ate eight meals a day, you'd every two hours, try to keep meals a day. Yeah, when I got to that school, that 30 grams of protein for meal, get that amino drip going in was the idea, right? Like just have an IV hooked up of amino acids. Not really, folks. Not really. Yeah. Yeah, that was kind of the concept, but the first study I did, we basically looked at, okay, a lot of people had measured the amplitude of protein synthesis in response to a meal. We wanted to see how long does this last and where does it peak, right? And so my thought was, okay, well, it'll probably track with plasma leucine. You give, for those that are not familiar, leucine is the amino acid that is almost exclusively responsible for increasing muscle protein synthesis when you eat protein. So it's one of the branched chameleonal acids. So we wanted to see, okay, how long does this affect last? So we fed these animals way protein. And again, I thought, okay, well, however long plasma leucine stays up, that would be how long proteins synthesis stays up. And so we got the protein synthesis data back and it was peaked at 90 minutes, or sorry, peaked from 45 to 90 minutes, and then was back down to baseline by 180 minutes. And so when I went to do the plasma leucine analysis, my shock was at three hours, plasma leucine was still plateaued out. All right, so okay, well, when I look at the initiation factors, that will show me something. So for those not familiar, this is part of the mTOR signaling pathway. So one of the two of the targets of mTOR, when it's stimulating, leucine stimulates mTOR, two of the targets of mTOR are a protein compound called 4EBP1. And then another one is called ribosoloprotein S6K. So I don't want to get into the specifics about it because it's kind of beyond the scope. But basically, when these things are phosphorylated by mTOR, it increases the rate of transition initiation, which translation initiation is basically the process of the ribosome, hooking on to the mRNA, and then starting protein synthesis. So I was looking at the phosphorylation of 4EBP1 and RPS6. And I was like, okay, well, I'll probably see these things come down at three hours, still plateaued. And so then it was like, what is, what's going on here? So I kept, I actually kept rerunning the data and rerunning the data and rerunning the data. And I don't ever forget, I went into layman's office. And this is like, you know, six months after we've done this study because this analysis takes time. I was like, so where are we with this duration study? I said, well, I just got to run the plasma data again because it's not right. And he's like, well, why is it not right? And I said, well, it just doesn't make any sense, you know? And I kind of went through, he's like, well, like, describe to me your technique. Like, how are you doing this? And I described it. And he said, well, how's your standard error? I told him what the number is where he said, it sounds like it's good data. He said, it sounds like you are trying to get the data to fit your conclusion and you need to change your conclusion to fit the data. And that statement, this is why we do PhDs. This is why, yeah, you need an advisor. This is why I'm so skeptical of everything because I have had so many of my ideas crushed by my own data, right? So we actually ended up this kind of effect, this phenomenon is called muscle protein synthetic refractory period. So basically, like, once you trigger the system, it kind of runs for a defying period of time and then it takes time to essentially reset for lack of a better term. It's also been referred to as the muscle full effect. But so I looked at that and said, why am I eating every two hours then? And there was even a study out of Wolf's lab, like back in 1999, I think, were they infused to me, you know, essential amino acids for six hours. Protein synthesis went up, peaked at 60 minutes, came back down 120 and never went back up again. Maybe I'm being naive, but I would have thought that if protein synthesis goes up and then comes back down, that eating more often would be exactly the thing you would want to do. So the goal was to get increased protein synthesis because you'd be pinging the system periodically. But the problem is the plasma amino acids are still elevated, so it's essentially like eating the whole way through from the perspective of losing. From the cells. Yeah. So that was one of those things where I said, you know what, I'm actually going to eat less often because like if I'm eating in three hours later, I've still got, you know, capped out plasma amino acids, you know, and we looked at all kinds of stuff. Like we looked at intracidolucine just to make sure that, you know, that wasn't falling off. We looked at all the plasma essential amino acids because, you know, we were thinking, well, maybe protein synthesis is, you know, sucking some of these amino acids out of the plasma and they're dropping and that's causing it to kind of short circuit the system. That wasn't the case. It just essentially what the evidence suggests, I think where there only wants to show this so far. So I'm not ready to say that this is a real effect because I hold out the idea that data artifacts do exist and you can't be totally sure. And we saw an increase in AMP kinase kind of around this mark where protein synthesis started falling off and we also saw a decrease in intracidolucine ATP. And protein synthesis is an ATP dependent process. And so what we think might be happening is you're, you know, consuming protein and you're up for your increasing muscle protein synthesis and then at a certain point, it's has enough effect on your, you know, energy metabolism in your cells that a kind of short, not short circuit, but it kind of cuts it off, right? So again, we're the only ones to show that that I'm aware of. So, and that was again, enrats. So I, I, I always talk about data like those data I'm willing to bet my, my toe on, my foot on, my leg on and my life on. I'd probably barely bet the end of my little toe on that one. I'm not quite sure, but it's interesting nonetheless. So that's a great example of, okay, we're looking at this mechanism of intracidolucine signaling. And if we just looked at that, we'd say, oh, well, protein synthesis is going to stay elevated for, you know, past three hours, but that's not what we saw. So yeah, I think it's, again, that's why I really try to, you know, get people to say, well, it's mechanisms are important. And especially if you're seeing an outcome, it's important to identify mechanisms that may explain that. But let's step back from the mechanisms from trying to chase mechanisms and let's look at like chasing outcomes in terms of what we recommend to people. Excellent point. In terms of chasing outcomes, a number of people I know are interested in weight loss or weight maintenance. And several times throughout today's conversation, we've come back to this issue of satiety signals, whether or not they're brain-based, body-based or both, you know, not wanting to eat more is a great way to maintain or lose weight because you simply don't want to. I heard you mentioned earlier that protein and maybe specific types of protein or sources of protein may provide better satiety signals than other macronutrients. Could you briefly talk about how macronutrients, including protein, but also carbohydrates and fats, impact satiety, and from the standpoint of somebody who, for instance, would like to quote unquote, lose a few pounds, right? Probably would be happy to gain a little bit of lean body mass provided it was in a particular location on their body. That seems to be a thing now directed hypertrophy, if you will. And how much they should focus on protein as a core component of creating this diet, you know, assuming everything else is being done correctly. They're going to hit the right number of calories relative to their output, meat, etc. How should we think about protein and satiety signals? And our animal sources of protein, indeed, more bioavailable. That's a tricky word. It forsake a muscle building, but also forsake of somebody who just would like to lose body fat. They don't want to lose muscle and they'd like to bring their weight down a few pounds. So a lot of things to unpack there. Of the macronutrients protein is definitely the biggest lever that you can pull because even if, you know, it doesn't take a ton of protein to get a lot of the muscle building benefits. I mean, I think the benefits really start to plateau out around 1.6 grams per kilogram of body weight. There's some evidence that maybe even up to like 2.4 or 2.8 grams per kilo may give like a little bit more benefit. I think it probably looks something like an asmto in terms of a curve where as you put more into the system, you always get a little bit more, but it just gets to the point where it's so infinitesimally small benefit that it's for all intensive purposes, no benefit. But you mentioned 1.6 grams of protein per kilogram of body weight. Is it, would you consider that a threshold that most people should try and achieve daily? I think I see very few downsides to hitting that. I mean, I know some people, and this is going to get into a separate conversation, but I know some people say, well, I don't want to stimulate mTOR because that's going to make me die early, and I think one of the things to keep in mind is if you look at this kind of thought process out there that if you're stimulating mTOR, the protein is going to make you die early. And first off, we have very little human outcome data to support that claim. And the second thing is if you look at any macronutrient isolation, I can make a mechanistic argument that it's going to kill you. So fat, if you take in fat, it decreases flow-mediated dilation. So that dilation is important for heart health in the short term. Cobb hydrates stimulate insulin, insulin, pro-inflammatory, and all these other things. And so I can make an argument for any single macronutrient to be negative for longevity. I really want people, this is something that even scientists get wrong. They look at an acute response of something and assume that that is going to relate to long-term outcomes and signaling. So let's just take exercise, for example. If I, if you didn't know anything about exercise, and I said to you, Andrew, I'm going to do something that's going to make you, your heart rate go up, your blood pressure go up, your inflammatory markers go up, your reactive oxygen species increase, you're going to say, and it's going to damage your muscles, you're going to say, I'm not doing that, that sounds horrible, you know, but it does all those things in the short term. But what is the long term effective exercise? You actually get healthier, all those things improve. Now, I'm not saying that protein is a longevity hacker or anything like that, but what I'm saying is I think some of the arguments out there based on mechanistic, you know, this increases in toward therefore we don't want to do it. I think it is a much more complicated argument than just that. So there's that. So protein is the biggest lever I would shoot for 1.6 grams per kilogram. If you can do more, great. There doesn't seem to be really downsides to it, even like up to very high levels of protein Jose Antonio did a study. There was a year long randomized control trial. And again, it's just one year, but they were looking at all sorts of different biomarkers. And basically even up to like four grams per kilogram of protein, they couldn't really find any negative health outcomes from it. Both of them people were just so satiated they ended up eating less calories. So protein is a big lever because one, it has a higher thermic effect of food. So you're getting a little bit more calorie burn per day, even though it's not a ton because TEF is a pretty small percentage of your overall energy expenditure, but still benefit. You're getting the effects on lean body mass. It's going to, if you're in a diet, it's going to help preserve lean body mass. If you're at maintenance, it's going to help build a preserved lean body mass. And if you're in a surplus, it's going to help build a preserved lean body mass. Then you get the effects on appetite. So now I want to be careful because appetite effects tend to be very specific to individual foods, right? So you can take a high protein food and make it not very, not very satiating. So take for example, like a really tasty protein bar, which, you know, back when we were getting into this, there was no such thing existed. Now you have protein bars actually take pretty darn good. But if you, one of them, I mean, are you really satiated? I don't really feel satiated. That's my protein bars. That's my premium snack. Right. Right. So why? Because I mean, it's processed, refined, and made to be very palatable, okay? But take something like a 200 gram chicken breast. Very satiating, right? And that's why when people say, well, carbohydrates aren't very satiating. It depends on the carbohydrate. I mean, when you look at the, like the satiety index, a plain baked potato is about as satiating as it gets. Like if I eat a bowl of oatmeal, I feel pretty good afterward. Yeah. For a while, right? I mean, I usually I'll eat that along with some other things. But I completely agree. So you're saying that the form that it comes in, maybe even how much chewing is required, how good it smells that your psychological associations. Because to me, a steak is an incredible meal. Like, I mean, if I had to pick one food that I could eat, even though I'm not pure carnivore, for the rest of my life, it would be that because I think it would get me where I need to go. And then I'd probably have to sneak some fiber. But it's an excellent point. I have a question that I don't want to take us off track, but I'm hoping it relates enough that you could answer it now. In the context of this, if I'm going to eat, let's say, two grams per kilogram bodyweight protein, and I'm not eating multiple meals, maybe I'm eating two or three meals per day, I'm certainly going to be eating more than the 30 gram threshold that was thrown around for a long time that we can only assimilate 30 grams of protein per meal. Should I just not worry about that? Some of it is going to go towards the thermic effective food. Some of that might be converted into glucose of all things, gluconeogenesis. So should I worry about this 30 gram cut off? Because I think balancing the 1.6 gram per kilogram bodyweight threshold with number of meals, you need to exercise and work and live my life and sleep, etc. Pretty soon you run into bottle necks where you just can't do it all. Or you're spending so much time trying to focus on it. You can't optimize all the things at the same time. You lose your mind and your body. So what is necessary in terms of frequency if one is getting enough protein? And then tied into that question, is there any reality to this idea that if you eat one meal per day or you're fasting and then you eat, you'll let's say 200 grams of protein in a single feeding that you can assimilate more because you were sort of protein starved. Is that a real thing? So most of the studies with protein are after a fast. Like because to assess it with stable isotope, you have to be in a steady state. So we haven't observed that. It doesn't appear that fasting really kind of allows you to assimilate more protein after a fast. So this gets into a core of one of the things I looked at in my PhD, which is does protein distribution matter because most Americans get about 65 to 70% of their protein at dinner. Breakfast tends to be pretty minimal protein foods. Do any cultures actually a big breakfast and not a big lunch in dinner? I guess so. We all heard that that was ideal. We'll get into circadian timing in a little bit. Does anyone actually do that? Staking eggs for breakfast and then taper off the rest of the day? I know German culture tends to have a big breakfast, but it also tends to be like sugary foods and whatnot. As far as like teleologically, I'm actually not sure about that. So if you look at that and then you consider that protein doesn't really have a storage mechanism, right? Like people will say, well, lean tissue is a storage mechanism. That's like saying a house is a storage facility for wood. So yeah, if the house is made out of wood, you could get wood out of it, but that's not why you build the house, right? Like you're building the house out of a demand, the same thing for a muscle tissue. There is a free pool of amino acids, but it's very, very small. So when you consider things like fat, which basically has unlimited storage capacity, carbohydrate, relatively large storage capacity, you can store 400, 500 grams of carbohydrate between your liver and muscles. And then protein, which almost has no storage capacity, the idea that, okay, you could make up for a low protein at one meal by overconsuming another meal didn't make sense to me. So one of the studies we did, and again, in rats, we took both groups, we're getting way protein. So high quality protein. They were getting the exact same amount of calories, exact same amount of nitrogen, exact same macros. Everything was the same. The only difference was one group basically got kind of three meals of similar amounts of protein. Dinner was a little bit bigger because we wanted to keep it somewhat similar to how people eat. But each meal was going to be over the threshold to stimulate muscle protein synthesis. Whereas the other group, I constructed it. So the first two meals of the day should not stimulate muscle protein synthesis. It should be under that threshold. And then the last meal was about 70% of their total daily protein. And so we had them eat those for 11 weeks. And I'll never forget this. This is how like obsessive I became about it is there was 110 animals in this study. And I made all the diets and I weighed out exactly every single meal for every single animal for 11 weeks. So I was in there at 6 a.m. I was in there at, you know, noon and now I was in there at 6 p.m. You know, I love it. That's it. And I kind of PhD student that professor is dream of. You were someone that dreamed student. So at the end of 11 weeks, we looked at like lean body mass. We looked at body fat. We looked at, um, uh, hind limb weights. We didn't really see differences in lean body mass. But what we did see was a difference in hind limb weights. It wasn't massive, but there was a significant difference in the size of the muscles of the hind limbs of these animals. And so it's interesting that there wasn't a difference in lean body mass. And what we found at least with the liver, the animals that were eating, uh, the, like one meal with really high protein actually had bigger livers, um, not like a huge amount and not something that I would consider unsafe. But they, it was a statistically significant difference. And so to me, at least like I'm trying to explain like no difference in lean body mass, but a difference in these hind limb weights, maybe there's some like sequestering of, you know, uh, like that, that that's fueling a little bit more, uh, protein synthesis of the splintnick tissues rather than, you know, cause you're capping out skeletal muscle protein synthesis. And we do know that the splintnick tissues are more sensitive or have a greater rate of protein synthesis per day. Like the rate of skeletal muscle protein synthesis in humans is about like 1% per day. So it takes like 100 days to turnover, you know, skeletal muscle, whereas like your entire gut, your entire GI will turn itself over in like two to three days, right? So the very, really, and the liver also has a very high amount of protein synthesis, which is one of the reasons it's actually one of the most metabolically active organs. So all that to say it has not, it's been, there's been one human study that showed something similar, um, and then there's been a couple others that didn't. And then in the intermittent fasting studies, which is maybe a good tool to look at compared to continuous feeding, it, one thing I will say is it looks like the 16, eight intermittent fasting style. There's been a couple studies with Grant Tinsley. Um, and this is something I've changed my mind on as well. Grant Tinsley has done a couple studies where they did use the 16, eight protocol. They had them trained during their feeding window and they had them eat, I think it was at least three protein containing meals during this eight hours. These are humans. These are humans. And they saw no difference in lean body mass at the end of the study compared to people who were eating, you like, you know, as many times as they wanted throughout the day. Now if you look at some of the more, uh, extreme forms of fasting, like alternate day fasting or like 22 or 24, there are some studies where you do start to see differences in lean body mass. So my suspicion is, and I'm, I'm just guessing, so this is tenuous. My suspicion is probably if you're getting like two to three, like high quality protein meals in a day, uh, you're getting the vast majority of the benefits of protein that the most important thing is getting enough total. Uh, and then secondarily trying to get, you know, at least two or three meals with high quality protein in. But if you're going like pretty extreme with like alternate day fasting or, you know, maybe only one meal a day, then I think there may be some effects on lean body mass. But again, these can be mitigated as well if you're doing, you know, hard resistance training. Typically, that is the biggest lever in terms of lean body mass. Yes, you know, protein distribution may make a difference, but I'm trying to put it in context so people don't feel like they need to go out and eat, you know, four meals a day. But again, so what I would say is like some of the more milder forms of, you know, time restricted eating appear to be fine for lean body mass. Now the caveat is the following. One of the nice things about animal studies is when you consider if you want to have a high subject number, high level of control and a long duration, it's pretty much your only option, right? So I have a, in our research review, uh, reps, I created a Venn diagram, which basically is like three, you know, circles crossing over one is study duration, one is level of control and the other one is subject number. And to get all three of those circles to cross over, it almost has to be in animals. Right. So in this and reps is it's a newsletter or a book. So it's, uh, it's our monthly research review. So every month we review like five, um, studies that come out in fitness and nutrition, like we'll usually do at least one nutrition, one training and one supplement per month. We will put a link to where we can sign up. This is a sign up format. Great. Yeah. So it's a subscription based service. So basically when people might look at like my study, well, why did you see a difference in muscle weights? Whereas some of these other studies don't see a difference. I weighed out every single meal for 11 weeks and keep in mind that 11 weeks in a row and it's a really long time. That's about an eighth of their total lifespan. So is it that there's no effect or is it that the effect is relatively small and would take a really long time and very high level of control to see in humans? I don't know, but I think what I would say relatively confidently is if you're going to do like a 16, eight intermittent fasting, you're probably fine, especially, and again, what is the goal, right? Like if you're a bodybuilder looking to be the most massive person you possibly can or you're a football player, you're some in some field that having as much lean body mass as possible is really important for you. Then I would say we're not really gaining a whole lot by doing some form of time restricted eating. I think most of the people listening to this do not fall into that category. Right. To maintain or lose weight, they'd like to perhaps add a little bit of quote unquote shape or muscle to specific areas of their body and lose body fat. And I think your normal forms of time are restricted and you're probably perfectly fine for that, right? And again, I don't want somebody to think, well, I do, you know, alternate day fasting. There's no point to be resistant training because I'm going to lose muscle mass. No, no, no, no, no. You can still build muscle doing that. You just might not build as much muscle as you would if you were eating in a more traditional format. That's something that works for you and your goals and especially if it's fat loss or, you know, controlling your calories. Then again, it's about the hierarchy of what's important, right? So to answer your question, I do think that timing and frequency matters, not so much frequency, but distribution more so. So I think the distribution matters, but it's a much smaller lever than just getting enough total protein in. And then as far as like animal versus plant, I used to be in the camp of there's no way somebody can build as much muscle on a plant based diet. And now I think I've come back to you can it just requires a little bit more planning. And I don't want to say always, but it's very difficult to do without an isolated source of protein. So unless you're going to supplement with an isolated plant source of protein, it's very difficult to get enough without going over on total calories because you can figure that especially like takes somebody who may be calorically restricted, trying to get enough protein from whole intact plant sources. So you've got a few different things working against you. One, the sources of protein you're consuming also have carbohydrate and or fat. Two, it's a less bioavailable form of protein. And three, it's a lower quality of protein in terms of it has typically less lucine, less branching amino acids and less essential amino acids. You answer the question that I almost interrupted you to ask, which was does it boil down to the lucine content? And it sounds like that is one of the components and that a lot of the vegan and vegetarian sources of excellent protein, that excellent protein vegetarian or vegan source is co-packaged with calories from carbohydrates and or fat that make it hard to stay under the chlorothreshold. Whereas a steak is, I'm not, and obviously people might want to avoid that for ethical reasons, but that's a different matter entirely. But a steak or a piece of chicken or an egg has a yolk which is there's fat there, but is almost a pure protein fat source, there's no carbohydrate along for the ride. So I think what I would say is that you can do it, takes a little more planning. And you're almost always, if you're a vegan, especially, you're going to be better off like suppling with some isolated form of protein or vegan form of protein. Now, this word gets into people say, well, what about the limiting amino acids and those sorts of things? It's a consideration. Some of the better forms of vegan protein in terms of amino acid content are like soy. Now I can, I hear everybody screaming online about their testosterone levels. In terms of actual outcomes and looking at testosterone, there was a recent meta-analysis looking at soy. And I think if it's your only source of protein, then maybe the dosage is high enough to cause some weird effects, but if you're just using it like once or twice a day, it doesn't seem to have an effect on testosterone or estrogen. So that can be a decent source of protein because it is a complete protein source. It does have a PD cause of one which PD cause is basically a measure of protein quality based on does it provide enough of all the amino acids so that none are limiting. And so soy is one of the only vegan sources that does that. Interestingly, potato protein, isolate actually has a similar essential amino acid content to weigh. So isolated potato protein, it's just really hard to find. I've been trying to sort of take note, vegetarians take note because or vegans rather because weigh is vegetarian and weigh is a very high quality protein. They're actually creating weigh now out of, I think it's, I may mischaracterize this, and I believe they're able to produce it now out of like yeast or something like that. That, you know, so for vegans, now this is a great option because you can have way that's not animal based that is going to be every bit as good as an animal based way. So I think that's great. Getting to the loosing, let me go back, sorry. So another reason that the using an isolated protein can be helpful is because it's more bioavailable as well when it's been isolated out when it's the protein bound up in the actual plant material, it tends to be less bioavailable. Now, cooking can help increase the bioavailability because it breaks some of those bonds and whatnot, but it still seems to be lower. And you don't, it's really interesting. There was a recent study where they did a corn, wheat, and peblend of protein versus whey, and basically the outcome was 30 grams of each stimulated protein synthesis to a similar degree. But the plasma amino acids in the plant-based protein still did not get as high as with whey. Now, it may be that that's just, it doesn't matter because once you get to a certain level, you get all the benefits. So I still found it interesting nonetheless that they didn't quite get as high. And the other thing to consider with the vegan sources of protein is the losing content. So one of the studies we did was we looked at wheat, soy, egg, and whey. Isinitrogenous, meaning we equated protein between the groups. Isocloric, we equated calories, and we looked at muscle protein synthesis. And I think this was, the meals were 15% of total energy from protein. So like your food guide pyramid level of protein. And we saw that in the wheat and soy group, they did not increase muscle protein synthesis, but the egg and whey group increased muscle protein synthesis. Now what's really interesting is we went back and we took wheat and added free leucine to it to match the leucine content of whey, and the protein synthetic response was identical. So again, I don't like to simplify things too much, but leucine appears to really be driving this ship. And I'll never forget, layman called me in his office one day, and he would always do these like thought experiments of he like, he liked to think about why something occurs the way it does. Dangerous, dangerous territory. Yeah. So he would say one day, I'll never forget, he's like, Lane, why do you think the body evolved to just sense leucine for muscle protein synthesis? And of course, I'm like, I don't know man, I just work here. I'm just trying to get my PhD. And he said, well, think about it. You would want something that really wasn't extensively metabolized by the gut and liver because you would want to show up in the blood in values that reflect what you just ate, make sense. And you would want it to have passive diffusion across the muscle cell because you wanted to be concentration dependent, which it is. So get into the tissues and cells that need it most. Right. So, you know, not having active transport, but rather passive transport. So yeah, I thought that that was really interesting the way he broke that down. So, few different options for the vegan folks out there. You can use an isolated source of protein. And again, like there's going to be good options coming because this plant-based way is going to be a great option for folks. You can add free leucine to it to whatever your source of protein is. Just buy, supplemented, leucine powder. Now, it tastes horrible. Yeah, I think I've heard that. Maybe I've even tried it. It's completely non-polar. It does not dissolve in anything. It can't be put into capsules. It can't be put into capsules. Yeah. So, you could take a capsule. Like, for example, if you're eating your normal meal, you could just take a capsule of like one gram of leucine. It's probably going to bump you up enough that you're going to be good to go. And then there's options like blends, especially with corn. Corn is actually very high in leucine as a percentage of its protein. Now, you've got to remember, like, you go eat corn on a cob and you're getting like two grams of total protein. So, it's not that much leucine. But if you isolate out the protein, put it into a powder. Well now, you know, when you're getting like 80, 90 percent of the weight is now protein, corn is actually about 12 percent leucine in terms of the protein. So a great source of leucine. It is like almost frank deficient in some other amino acids. But you can blend it with a few other sources of protein like you could blend it with a soy, a pea, and you can create these complementary blends that would actually have quite a bit of leucine, but also some of the other essential amino acids. So there are options out there for plant-based folks. And I mean, we have seen people who are plant-based, you know, build impressive amounts of muscle. There's quite a few bodybuilders that are plant-based. And a lot of them during satellites like it. Even though when we talk about muscle, we think about muscle building often, performance in endurance sports, and also just performance for the typical person who's doing some cardiovascular training, hopefully some resistance training also, and just living life. I mean, many more people now, it seems, are vegan or at least avoiding meat in particular red meat. I'm not one of those people. I limit the amount and I certainly focus on the quality of what I eat, but I do eat red meat. It brings me to a question about, you know, just generally in terms of food choice. You know, can we come up with a relatively short summary of the following? Tell me if this is correct or not. That most of us should be focused on, for sake of health, health span and lifespan, should be focused on ingesting minimally, non-processed and minimally processed foods, maybe even cooking our own food. I realize that's heresy now, but ideally we do some of that. And really trying to avoid foods that are highly processed and have lots of sugar. And I'm using this as a segue to get into a question that I really want your answer to. I've been dying to ask you this, which is if sugar intake is not actually going up as much as people think it is, why are people getting so much fatter? So what do you think about just a general statement that we should try and eat foods that are low to no, minimally to not processed? For about 80% of our foods, is that a reason to remember? It's hard to actually get completely unprocessed food because almost everything goes through some form of processing. So I'm thinking that anything that wouldn't survive long with a shelf, yeah, on a shelf, like an apple or banana or something, oatmeal, like ground oats to me, as long as there is a bunch of other stuff and there would be minimally processed. A stake is not really processed, although it's cut off the animal, etc. So there's a few steps in there, but that's what I mean. Yeah. And I think everybody gets the gist. I'm probably a little bit pedantic when it comes to this stuff. No, this is good. Actually, one of the things I appreciate about you is something that I get teased a lot by people close to me, which is the caveats and the insistence on precision is really important because especially with online communications these days, it's like a runaway train. Yeah. You know, people will... It's too easy to misinterpret what you're saying. Very easy and misinterpreted. And the misinterpretations are often used to leverage whole new ideas about what isn't isn't true, mostly about what is true. So I really appreciate the nuance and this is what a long-form podcast really allows us to do is catch every curve. So I would 100% agree with what you said that if you were going to make a broad stroke that trying to focus on minimally processed foods is very important. The one caveat I would say is I think it's important to understand why because otherwise people can make this weird association that like if I eat any minimally or any processed food, it's going to kill me or like every time I eat it, it's like I'm smoking a cigarette and my health, you know, my longevity is declining. Based on the studies we have, it's mostly about the energy that processed food just gets people to spontaneously eat more. And Kevin Hall showed this in his study that was very... I mean, he designed some of the most elegant studies in nutrition. He's great. And they basically took people from a minimally processed food diet and then gave them access to ultra processed foods, very few instructions just to feel satisfied. And they spontaneously increased their calorie intake by 500 calories a day. I mean, that's massive. So there's... And we quite haven't quite figured it out. People say, well, it's sugar. It doesn't appear to be sugar in terms of just an isolation. Well, it's fats. Then it appears to be fats and isolation. Well, it's the combination of sugar and fat. The heartly, well, it's the combination of sugar, fat and salt. Partly, but there's some kind of overall magic to the texture and the mouth feel and just the overall palatability of stuff, which is always why I say there's right and wrong ways to these different diets. For example, there's a right way to do plant-based. And then there's what's in some of these documentaries where they're eating plant-based mac and cheese. And again, I love a good mac and cheese, but that should not be pitched as a healthy diet just because it's plant-based. Because I mean, you're eating a highly processed food that's very palatable and easy to overeat. Same thing for keto. You've now got keto ice creams and you've got keto cookies and all these sorts of things. And I'm like, yeah. And if you look at them, they actually have more calories than the normal stuff. And I'm like, yeah, this is completely missing the point here. Like you're actually just taking yourself... The whole point of those diets is the reason you tend to lose weight is originally good luck 10 years ago doing a keto diet eating processed food. Like you just couldn't do it really. Now you can. But the problem is it's not going to work because you're going to be still consuming too many calories because even though it's keto, what are they doing? Well, they're trying to make it more palatable. They're trying to make a better mouth feel. Which I guess if you're being keto for the sake of being keto, great. But if there's... If you have hopes of body composition modification, it's going to, you know, really negatively impact. So yes, I think minimizing the amount of processed food you consume can be important. Now that being said, it depends on the individual and their goals. If your goal is to, for example, build muscle or maintain a high body weight for a sport, for example, like an NFL offensive lineman or something of that nature. Or if you're... You know, I worked with an NBA team. They were kind of... I can't disclose anything, but they were looking at drafting a certain player. And, you know, like for them, processed foods may actually be a tool for teenagers. Right. And we all want young people to eat more healthily, I think, develop great habits. But some of them, their caloric needs are so high that if they were eating what I eat, they're going to dissolve into, you know, they're just waste away. So I described this again with a financial example. It's like a budget, right? So if I make a million dollars a year, for example, is it okay for me to buy like a $100,000 sports car? Let's assume that loans don't exist, right? Is it okay for me to buy a $100,000 sports car if I still am able to pay my mortgage and pay my utilities and like take care of my responsibilities, the things I should do? Is it okay if I do that if it like makes me feel good and it's fun? Yeah, it's fine, right? Like it fits in your budget. But if I have, if I make, you know, 50 grand a year, should I be going out and, you know, buying a sports car? Probably not because I'm not going to be able to pay my mortgage and all these other responsibilities. So you're, you're protein, you're fiber, you're micronutrients, these are your responsibilities. But those become much easier to hit when you have higher calories, right? So if you're, if you're, you know, eating 4,000 calories a day for whatever goal you have, you're probably going to have some leftover and like good luck eating 4,000 calories from your mentally processed foods. You, quite frankly, you'll be miserable because you're, you're going to have such gut fill that you're going to feel like you can't even move. And so again, now it becomes, okay, well, is there something inherent to that food processing? Is there something, you know, that we can pick out that we know, okay, well, this is going to be a negative effect on health, even like body composition stuff aside. And I would say there's not really great evidence of that so far. And a great example of that is sugar. I mean, I actually just wrote a really long article on my website about why I think sugar was not the root cause of the obesity epidemic. And you kind of mentioned like sugar intake in the last 20 years has actually gone down a little bit. Alcohol intake. Well, if you look on the whole, it might have gone up a little bit, but you know, certainly in the male sector, it's gone way down. Drinking used to be, there was a five o'clock people drinking all day. People are smoking a lot less. And I think it's a real puzzle. I'd love to know what you're. I was talking to actually being opposition because nicotine is actually an appetite suppressant. And also increases focus. The problem is it often arrives in a delivery device that can kill you. But nicotine itself is a powerful agent. It also can offset age-related cognitive decline, not entirely, but it makes the brain work better. I've got a buddy who doesn't like caffeine. He just takes those nicotine pouches and like basically has one in almost all day because he's like a, he has a very stressful job and is a high performer, you know? Yeah, I have to be careful how you deliver it. But there's a Nobel Prize winning neuroscientists that will chew five or six pieces of nicorette and hour, which I do not recommend. But when he quit smoking, he just simply couldn't function as well. And he was the one who pointed me to the literature on offsetting age-related cognitive decline, even neuron maintenance. It's pretty interesting. Well, it's a pretty, it's a pretty impressive neutropy to be honest. So now the first thing it realizes when we're talking about consumption data, this is based on actual production, basically. They're assuming that, okay, we're producing this amount of these foods so we can assume the consumption is going to follow that. So it's not a direct measurement. But it has been validated in a few different studies. We know that oral consumption has gone up. Like that's, that's, yeah, that's one of the big ones is in this kind of, you know, kind of forms the crux of like the seed oils or like the root of the question that I'm going to have. They're going to, you know, come into your house and kick your dog and, you know, punch your mom and all kinds of stuff. And I'm happy to address those. But so calories have still gone up. There's some people who claim that they've gone, they've kind of plateaued. I think the data seems to suggest that calorie intake is still increasing. And the other thing to keep in mind is, even if it's plateaued, it's still at a high enough level that obesity is probably going to continue to increase up to a point where it'll probably plateau if calories are plateaued. What about energy output? Leaving aside meat because that sounds highly individual. I mean, people are, the people we know are focusing on exercise. There are a lot of folks out there that don't exercise. And, and, and energy output has gone down over the years. I mean, and it's very obvious when you look at how people work now compared to even, you know, 30, 40 years ago, it's much different. Less talking. Also, I learned recently that kids in high school don't take PE class in many schools. We had to suit up and run and suit up. And if you didn't bring your change of clothes or you didn't wash them in which case, you'd be better off just not wearing them. Nothing like the smell of a boys locker room after a weekend, you know, it's still remember it. And it's not, it's not pleasant. But you had to run and do your pushups with everybody else or play volleyball in your, in your regular school day clothes. So that, I'm, my understanding is that physical education is not part of the basic education any longer. I'm probably depends on the state, but I know many states have done away with it just because of budget cuts. So activity's going down. Colouric intake is going up. Maybe plateauing, maybe plateauing. Is that sufficient to explain the obesity epidemic? Uh, basically what I've seen, I, I, I think it's pretty sufficient. So it might not be that big of a mystery after all. No, I don't think it's a big mystery. I think that, um, people don't like the concept of energy balance. And I think because they insert judgment into it, which is, okay, if you're gaining weight over time at a fundamental level, it means you are eating, you're consuming more energy than you're expanding. People insert the judgment, which is you're lazy. You're a sloth or whatever it is. And I think there's a lot of people out there who actually think that I actually remember talking to somebody who's like, why would never hire an obese person for a job? Because it's just obvious that they're lazy. And I just remember going, are you serious? Like there are plenty of very, very smart, high achieving people who are obese. And I like it's not, this is what happens when you just put people in buckets, you know, like people are much more complicated than this. Yes, there is, there is some in personal responsibility. I think when you look through the data and you like take, there was a study done in obese women, where they found that women who were obese were 50% more likely to have had some form of sexual assault trauma in their past, right? We know that people from lower income areas are more prone to be obese. There's several like people who have a higher ACE score, I believe, which is kind of measures like traumatic childhood events. I believe there was a study showing them more likely to be obese. So there's, yes, it is an energy imbalance problem, but you know, just saying eat less move more, that's like telling broke people, we'll just earn more money than you spent. It's technically right, but it's very unhelpful, right? What is more helpful is to describe and implement the habits and behaviors that will allow them to achieve that, right? So I realized we kind of got off track a little bit, but circling back to like sugar, circa 2005, I believe that sugar was fattening and bad for your health independent of any other variable. So independent risk factor. And again, I want to be very clear about what independent means. Independent means independent of all of the variables. This thing is bad for your health and body composition. So on its own independent of whether or not, for instance, it increases hunger and appetite. Right. Or calorie intake, right? I was at a graduate school mixer and one of the professors there was somebody who had done research on high fructose corn syrup and fructose specifically as well. And he was talking to another professor and he had done this study in rotents where he had fed like, I think it was like 60 or 70% of their calories from fructose. And they saw some really weird things happen in the liver with the Nova Lepogenesis and all this kind of stuff. And the other professor is saying to him, yeah, it's pretty obvious that high fructose corn syrup is, you know, fattening. And this professor who had done this research said, yeah, because it's people overeat. And he's like, don't you think there's something inherent to it? And he said, no, I think it's just calories. He's reading too many calories. He's like, we did a proof of concept looking at, you know, could we like try eating 70% of your daily calories from fructose? You actually can't do it. Like high fructose corn syrup is only 55% fructose. So if you ate nothing but high fructose corn syrup, you would still not get to this level that they fed in this study. So that got me kind of like questioning my beliefs about it. So then I went through and I said, okay, like let's take out the epidemiology, not that epidemiology is useless, but people who eat more sugar are also likely to eat more calories. So then I looked for the randomized control trials where they, you know, match calories and vary the amount of sugar. And it doesn't seem to make a difference. At least from fat loss or fat gain, but what about health? So for instance, if somebody, and I know somebody like this who loves sweets is thin, get some exercise, not a ton. But my concern is that a significant fraction of their calories are coming from these sugary foods and therefore they're not getting enough fiber, maybe protein, etc. So let's look at epidemiology for a second and I'll address this more directly. When we look at epidemiology, people who eat higher amounts of sugar tend to be, you know, more obese and you tend to have, you know, worse biomarkers of health. But people who eat fruit, a lot of fruit sugar don't have those same associations. So why is that? Well, because fruit has fiber with it, right? So I started to kind of believe, based on the data I was looking at, that high sugar intake was not the problem per se. The problem was that high sugary foods typically are very low in fiber. But if you're getting enough fiber, is sugar a problem. So there was a classic study by Sirwitt in 1997. I think it's still the best study to this day looking at this. I know those people say, well, it was done 1997, it has no relevance. You know, I know if it's a good study, it's a good study. Some studies are timeless. In fact, they have greater revenues. But I'm going to go back and undo the discovery of DNA because it was, you know, 60 years ago, or whatever it is. So they, they looked at an 1100 calorie diet. So low calorie diet, one group was eating over 110 grams of sugar a day, like sucrose. The other group was eating about 10 grams of sugar per day. These protein, carbs, fats all matched, right? And they provided all the meals to these participants. So very tightly controlled. And it was over six weeks. Both groups lost the exact same amount of body fat. So it doesn't seem to matter for body composition in terms of like sugar per se. Then they also looked at some biomarkers of health, like blood lipids and, you know, blood sugar and some other things. Again, there was no real differences. The only difference was so all their biomarkers improved in both groups. The only real difference was a small difference in LDL. So the group eating low sugar had a better improvement slightly in LDL. But that's probably because they were eating more fiber. And we know fiber can, you know, bind a cholesterol and lower LDL cholesterol. So is now I want to, I want to caveat this. Sugar probably doesn't have any like positive health effects. So there's that, right? And nutrition is an exchange. If you're eating one thing, you're not eating another thing, right? So I, but what I would tell people is focus probably less on sugar, focus more on fiber. So if you're eating 30, 40, 50, 60 grams of fiber a day, but your sugar is, you know, 80, 90 grams, I would not be that worried about it, especially if you're controlling calories as well. You know, what I would be worried about is if you're eating, you know, just a decent amount of calories and not getting enough fiber in general, right? And even in studies, there's a few meta analyses out now looking at iso energetic exchange of different carbohydrates with sugar carbohydrates. So fructose and glucose and sucrose. Now, why is this important? Well, again, you know, if you're not equate, when I say iso energetic, that means equal and energy equal in calories. So basically when they exchange either sucrose or glucose or fructose for other forms of carbohydrate, do they see differences in these markers of health like HBA1C, fasting blood glucose, you know, blood lipids and with rare exceptions, and I can't remember all the data points exactly, but the take home is doesn't really seem to make a difference. Now before anybody out there, straw man's my argument, I am not advocating for sugar consumption, but I think it's important for people to not create weird associations in their minds because one of the things I've observed, especially in the fitness industry, is when people feel like they can't eat something, like it's one thing if you say I am choosing not to eat this just because I'm choosing to, but it's a very different thing when you're purposely restricting because you feel like something is bad. And this, this, I mean, you know the human brain is in many ways amazing in many ways really dumb. So when you purposely try to restrict something, what tends to happen is you're more prone to binge on it. So people who will try to, well, I'm never going to eat, you know, sugar again or I'm going to try and limit sugar. This isn't the case for everybody, but they have actually shown now in studies, people who are purposely restricting a specific nutrient, they tend to crave more of that nutrient. And if they do get exposed to it, they're more likely to have what's called a disinhibition reflex, which is basically a binge response because the thinking goes, well, this is bad. And there's no context on, you know, dosage making the poison. This is just bad in general. So if I have it, I've already screwed up. I might as well just have as much as I want. And I like Spencer Nudolsky's comparison of this is, you know, that's like, you know, getting a flat and going out and slashing your other three tires because, you know, you might as well. So I really, I try to come from that perspective of I've seen so many people struggle with, you know, maybe not an eating disorder, but disorder to eating patterns because of these kind of associations they've made in their mind. And so that's why I'm so pedantic and a stickler about saying, okay, yes, it's a good idea to eat the mentally processed food and try to avoid processed foods, but not because processed foods are bad per se, but what the outcome tends to be from a lot of processed food consumption, which is overconsuming calories. And then therefore, you know, energy toxicity negatively contributing to your health. Yeah, it seems like it again returns this the potential for a positive negative or neutral behavioral change and perceptual change of like craving a food all the time that you can't have is terrible. That's a terrible state to be in. And this I think is a perfect segue for something that first brought us together. Which was, you know, which was this thing about artificial sweeteners. And let me just for the record be very clear, I have long ingested foods with artificial sweeteners. So I throughout graduate school, I didn't have the best habits, they're healthier now than they were back then, but I would drink, you know, a Diet Coke or two per day. I still have the occasional Diet Coke. I'm not completely averse to drink something that has artificial sweetener. Although I do avoid sucralose for reasons that maybe I can get into a little bit later. But a lot of the things I consume contain stevia, which is not artificial plant, but it is a plant based non-chaloric sweetener or low-chaloric sweetener. And I don't have a problem with that. I became very interested in artificial sweeteners because of the animal data I'm pointing to the idea that they may disrupt the gut microbiome. And then disrupt the gut microbiome as you pointed out is a very broad statement. We don't really know the percentage of lactobacillus, etsylbacillus or whatever, or whatever sylis, illus in there. They all seem to end in illus is ideal. And in fact, a lot of these companies that are having people send in their stool samples for analysis of the microbiome, I mean, take note, we don't really know what a healthy microbiome looks like. But we know what an unhealthy microbiome might look like, and it's one that doesn't have a lot of diversity in there. So I was interested in that. Then there's the recent human study, which we should definitely get into. But I was mostly interested in artificial sweeteners for the reason that there is this food conditioning effect. And you see it in animals, and you see it in humans that if you ingest, well, coffees are really good example. Coffee doesn't actually taste good, folks, even though I like it. But when you taste coffee for the first time, most people think it's bitter and disgusting. Most everybody, like 95% of people say this doesn't taste good. Wine beer is the same thing. Yep. But people learn to associate the state of being caffeinated, which most people like, in order to just feel normal, right? Caffeines are one of the few drugs we ingest, just to feel ourselves enough that soon myself included really look forward to and enjoy a cup of coffee. So it's a powerful example, in my opinion, of the food conditioning effect. So it's like a Pavlovian thing, instead of salivating you crave, right? And it did seem that this study from Dana Smalls Lab, which admittedly was a small, no pun intended study itself, not very many subjects, showed that if you ingested artificial sweeteners along with food that contained glucose, that you could maybe even get a heightened glucose response just from the artificial sweeteners after a while. And I connected over this study on social media, you pointed out that the design of the study wasn't superb. There was co-consumption of glucose, which made it complicated. We can go into that. But the reason I'm spouting off all this context is artificial sweeteners are many things. So I'd like to talk about their effects on blood sugar in the acute sense, and according to what we might ingest them with, and how they might be changing blood sugar regulation at the level of brain and our body. And then, they've got microbiome data I think are interesting enough to discuss. And I have changed my view on artificial sweeteners based on what you've taught me. So this is a case where I've completely changed my view, which is that now I don't have any problem with them whatsoever based on the current data, which is not to say that I'm gulping down a cup full of superlose. But I feel okay ingesting some stevia and some aspartame, and I'm not too worried about it. Yeah. So I think kind of stepping back from a broad view, we have to think about, again, the hierarchy of importance, right? And what are you replacing with? Right? So there is no situation where it is not a net positive to take somebody who drinks sugar sweeten beverages and have them drink an artificially sweeten beverage. Like in the meta analysis, there was actually a recent network meta analysis looking at markers of an aposity, you know, HBA1C, a bunch of different health markers. And when you substitute, you know, we'll call it non-nutritive sweeteners since stevia is not artificial. But so when you substitute NNS for the sugar sweeten beverages, you see improvements in a lot of different things. Okay. What was really interesting about this network meta analysis was they also looked at water substitution in place of sugar sweeten beverages. And the effect wasn't as powerful as these are randomized control trials. So artificial sweetener containing beverages are more beneficial. We're better for adiposity, for improving adiposity. And then in the health markers, it was kind of a wash, water and non-nutritive sweetener beverages performed similar. But they were better than sugar sweeten beverages, obviously. So they then based on a network meta analysis is kind of where you can compare two things that didn't get compared directly. So there's not many studies comparing NNS versus water directly. But if you have a common comparator, so if you compare A to B and B gets compared to C, you can compare A to C based on how they interact with B. Noturing it a little bit, but that's kind of the crux of a network meta analysis. So they looked at NNS versus water and found that actually NNS was slightly better for improving adiposity. NNS, of course, being non-nutritive sweetener. Right. So now again, if you like drinking water and you don't want to, I'm not trying to convince anybody to do that. But that seems to suggest is there is a little bit of an appetite suppressant effect from these artificial sweeteners or non-nutritive sweeteners. Now this gets a little bit more complicated because if these were people drinking sugar sweeten beverages, maybe they've already developed a sweet taste and try to go to water. It's too much of a jump for them. And so going to having something like intermediate is a little bit better. Like, there's a lot wrapped up in this. But these are the randomized control trials, which are a little bit more tightly controlled, which I tend to default to a little bit more than I do the epidemiology, which epidemiology is just so messy because sure, non-nutritive sweetener consumption may be associated with different things. But there's also a whole other set of lifestyle and habits that are tied up in that. So I tend to hang my hand a little bit more on the randomized control trials. So understanding that, okay. Now all things being equal, understanding that this is a tool that may help some people. And whenever I post about non-nutritive sweeteners in the comments, there's always one or two or three people who say, all I did was cut out soda. And I drank diet soda instead and I lost 50 pounds or I lost 75 pounds. I even had one per se. I lost 100 pounds. That's the only thing I did. I mean, that's a pretty massive lever to pull. If you consider somebody who might be having like, I mean, five or six coaks a day, I mean, that's, you know, we're talking a serious amount of calories. And that also means that by replacing with artificial sweetener-containing beverages, they did not replace the soda with food. Correct. So like, let's now, let's talk about, right, this is where we can get into the microanalysis. But is that obese person who lost 100 pounds by doing that? Do I really care about maybe a small alteration to their begut microbiome? No, because their begut microbiome is actually much more healthy now by them having lost all that excess adipose tissue. So again, the ranking of what I'm worried about, you know, can change depending on the specific situation. Now let's take somebody like me who's lean and doesn't really have, you know, any health problems that I'm aware of. What about artificial sweeteners for me? Well for me, I kind of got using them because of bodybuilding contest prep because it was about the only appetite suppressant that worked for me. But do I think that they are healthful? Probably not. Do I think they're unhealthy? I would say based on the current data, I don't think that they're unhealthy. Now the information on blood glucose. So there's some of the problems with some of these men analyses or these reviews is they kind of lump all the non-nutrientive sweeteners together and then they may say, well, there's no effect on this or there's an effect on this. Well the problem is these probably are, these are different molecules and they can interact differently. And the upper team very clearly seems to have no effect on blood sugar or insulin. That has been repeatedly shown. Stevia doesn't appear to have much effect. Sacrifice and sucralose, the jury is kind of mixed. Now there was the study that we first connected on which I think their primary outcome measure was actually that we're looking at like kind of the sweet taste, like how it affected sweet taste. So what they did was the group that was getting the sucralose was also paired with maltodextrin. The control group was getting sucrose, which is an appropriate way to compare the sweet taste because maltodextrin is not as sweet as sucrose. So when you're trying to combine sucralose, which is already sweet with another form of carbohydrate, you want something less sweet compared to your control. But for the outcome measure of insulin and blood glucose, probably not as appropriate because we know maltodextrin has a much higher glycemic index than sucrose. Right. So they appropriately controlled for taste, but not for the effect of the sweeteners. And I think that that was a key component. And I think, yeah, the part of that study that intrigued me actually was in a talk version of that because that study drove me to watch a talk that we'll get Dana Small on the podcast at some point, hopefully, was that they had kids do this study. And they actually had to cease the study because a couple of the kids became pre-diabetic. I mean, it seemed like there was something hazardous about, this was at Yale School, medicine's good place. I mean, you know, there's a range everywhere, but it just seemed like there's something about sweet taste that if taken to the extreme might be able to impact blood sugar to the body. And this is impacted my sort of behavior. And though, I try to avoid really sweet things unless they're exceptionally delicious or the occasion calls for them because I do think that it increases my craving for sweet things. Well, it might not be necessarily a craving, but it just programs you. So let's, your taste buds are extremely adaptable. So take, for example, like Indian food, if you bring Indian people over to America and have them eat some more food, they think it tastes extremely bland because they are used to such spicy food that unless they have a certain level of spice, they hardly even taste it. If you've ever done a high sodium diet and then gone to a low sodium diet, it feels very bland. That's like styrofoam. But your over time, your taste buds adjust. So sweet is the same thing. If you're used to eating a lot of sweet, you get kind of desensitized to it. And then if you go to something less sweet, it can kind of taste bland at first. Over time, it'll get better. But so I think it's one of those things that, again, it depends on the situation, right? Like if somebody's obese and they said, well, this is going to help me eliminate sugar sweeten beverage, like why would you want to take that tool away from them? Like that's a great lever to pull. I mean, if somebody can lose literally a hundred pounds from just one change in lifestyle that's not even really that inconvenient of a change, that is powerful. But again, is it the most healthy thing they could do? And I think that's kind of like what tends to get asked. We don't know. Is it healthier than water? Probably not. Maybe as healthy as it. Who does? Now, the, but I really make all those caveats because you don't want to have people who could use this as a tool. Think, well, no, I can't do this because it's actually bad for me. If it helps you lose 50 pounds or 75 pounds or whatever it is, it trusts me. It's not bad for you, right? Well, it does seem to increase these satiety signals. What do you think about the microbiome effects in this recent study? Because the recent study, I think, had some nice features to it. And you've done a detailed description of the study. So for those that want that. Is this a two week study or the two week study? Yeah. And we will provide a link. You did an excellent video on this on your YouTube channel that really parses each piece. But they compared the various artificial sweeteners and looked at the glucose response, looked at microbiome, a number of different measures. What was your general take away? And this was in humans for the, for I think of the first time looking at microbiome in humans due to artificial sweetener. There are a few studies on the microbiome in humans with artificial sweeteners. The first two that came out showed pretty much no effect. But they were a little bit shorter in duration. They were like two to four weeks. And again, it depends on what bacteria are getting measured, right? Like there's many different kinds of bacteria. So they could just be measuring one that didn't change. And then there was a 10 week study that came out that they got a lot of press. And they showed, I think it was sucralose, I think. They showed an effect of change on the gut microbiome. Now what was interesting is when I went into the species that changed, the species that changed the most compared to control was a species called, I'm going to butcher the name, but let's like, bloudia, cacoidus, I think it's called. I must say for those that work on the microbiome, it's so difficult to pronounce. Different knowledge. You need a nomenclature committee and you need acronyms. I'm sorry. Just do it. Enough already. You're killing us. We'll call it BC. We'll call it BC. Thank you. We're going to start the nomenclature committee without you if you don't do it soon. So they noticed that this went up by like three to fourfold. So I kind of went down the rabbit hole on this. So interestingly, that particular species of bacteria is actually associated with lower adiposity, better insulin sensitivity, and people who are obese and children who are obese tend to have less of it. So I said, well, based on that study, you can actually argue that maybe sucralose actually improved the gut microbiome. Again, I'm not making that claim because we have a hard time understanding what a healthy microbiome looks like already. What this last study that came out, my biggest take home was I think it's safe to say that some of these non-nutriutive sweeteners are not metabolically inert. There are some effects. Now are those effects good, bad, or neutral, I think has yet to be fully elucinated? Now I focused more on the blood glucose responses in my analysis. So in that 10 week study, they looked at, they did it with glucose tolerance tests. And their conclusion, I didn't really feel like fit their data. So the conclusion was that, and again, I think it was sucralose, that it elevated blood glucose. And this is where statistics can get kind of tricky. So my take home was the area under the curve, the incremental area under the curve, which is looking at basically the entire glucose response, was not different between the control and the sucralose group. To me, that's the biggest take home. There was one time point at the end of the study in the sucralose group, the 30 minute time point that was statistically significantly higher blood glucose than the control group. It's kind of one of those things where I go, okay, it was at one time point, it's statistically significant, but even then we've seen things be statistically significant that end up being data artifacts because they're not reproduced. So I'm not saying that's what's happening here, but again, the overall area under the curve was not different. So to me, that was the biggest take home. And papers that we should probably mention are published because of effects generally, lack of effect, harder to publish. No hypothesis, it's actually really unfortunate because a null hypothesis is just as useful data as the non-null hypothesis, but you're right, there is a very strong publication bias towards showing an effect versus not. Yeah, unless you can flip a field on its head entirely by showing something did not happen, typically the positive result out does the negative result in positive meaning you see a result. And then of course it's one study. Yes. And I think that as you talked about earlier, the center of mass of data in a given field are probably the best basis for what we should do in terms of. And so I'm not changing my behavior around the intake of artificial sweeteners. I personally am still going to consume stevia and aspartame in relatively small amounts. But now I'm thinking, well, okay, if something contains sucralose, I don't have to perhaps actively avoid it. Whereas before I was, I was actively avoiding it. So the new study I thought was very elegantly, does it very involved. I mean, be quite frank, some of the animal stuff they did was extremely impressive. So there was actually two arms to this study. One was a human arm, one was the animal arm. I focused much more on the human side of it. So basically this was a two week study and the really unique aspect of this, which I think is both a strength and a weakness. They had almost 1400 people apply for this study and they only had 120, I think that actually went into it because they did a very detailed food analysis of these folks. All these people said that they avoided artificial sweeteners or didn't consume them. And I think people don't realize how ubiquitous sweeteners are. Prior to the study, these people were like, it was like jury selection. They had never, it's like not ever hearing of the plaintiff and the defendant. These are these mutant people who have never had an artificial sweetener. Right. The strength is now you don't have a lot of like pre-existing effects that may be clouding what would actually happen when you add it in. Like for example, if you have people who are already consuming artificial sweeteners and then you have them consume artificial sweeteners, the likelihood things are going to change is pretty low, right? So I think that that's a strength. It's also a weakness and I want to be really careful because I think people took my words a little bit too far, which means I probably didn't do a good job of being nuanced enough. There is the possibility for a placebo effect here. So to me, if somebody has gone through that much painstaking care to avoid artificial sweeteners, it's likely they have a preconceived notion that those are bad for you. Like to because they're difficult to avoid. Yes, it's possible if they're eating a very minimally processed diet that they're just not exposed to them. And that's very true as well. But the other thing that the researchers acknowledged was they weren't able to blind the study. Because if you've never had an artificial sweetener before, you're only used to like regular sugar and you have an artificial sweetener, you know. You taste it. You know. It's still sweet, but it's not the same sweet. And there's an interesting effect there where a lot of people don't like the taste of aspartame the first time. Yeah. I actually quit drinking diet soda for a while thinking I should and then had one. It tasted really, I can only describe it as kind of artificial chemical. And then pretty soon it tasted great again. Yep. And so there is some attenuation there and whether or not that's central meaning within the brain or peripheral, I don't know, but very interesting. Well, I see you as playing a critical role in defining what is and what isn't, what still needs to be determined in terms of this landscape and the entire landscape, really of nutrition. And that study did change my opinion in terms of, okay, I think we can clearly say now that like these aren't, these aren't neutral or sorry that they're not inert, right? Like that was the thought process before it was well, they're not digested or whatnot. So they must be inert. That doesn't appear to be the case. But again, like when we look at the the blood glucose data, there's, and I'm not saying this is what happened. I want to be very clear, not saying this is what happened. I'm saying it's possible this happened. And so this is why we need more studies to verify. If these people had a preconceived notion that artificial sweeteners were bad for them, it's possible knowing they're ingesting artificial sweeteners that they could have had a blood glucose response. Now, the my pushback on my own point there would be then we should have expected to see it in all the, in all the non-neutral sweeteners, which they didn't. It was just in sucrose and saccharine. It was kind of a graded effect where sucrose and saccharine showed the most dramatic change. And stevia and a few of the others did not. And the other issue I took with it, maybe it's a tic-tac thing was their primary outcome measure was blood glucose of the glucose tolerance test. But they had people administer their own glucose tolerance test, which basically they gave them, they said, okay, drink this drink and they were wearing continuous glucose monitors, which should have been fine. But again, to me, and I'm being tic-tac-y, and again, I know all studies are limited by funding. So, I think overall this was a great study, but I would have liked to see them monitor the, the, or glucose tolerance test to administer it after. Yeah, you want to know that they didn't ingest this or didn't ingest that. Those two things, but the other one of the caveat is it was a two week study, right? So we got to be really careful how much we interpreted this because it's also possible that this is a transient effect, right? And maybe it goes away over time. We don't know. But again, I think it's, we can clearly say it's not inert, right? Now, how much emphasis we put on that on a two week study, I, I still will say, okay, maybe if you're worried, don't consume sucrose, right? But if you're, you know, a hundred pounds overweight and you want to use some sucrose as a replacement to help you lose weight, I would say don't let this study deter you from doing that because the net effect is still going to be more positive than you not losing the weight, right? So if it's a tool that helps you, fine. But I do hold open the idea that well, there could be negative effects from it as well. But again, we're looking at like what's the, what is the overall outcome, right? And then when I looked at the examined like some of the different things that were increased with these different sweeteners. And again, this work, it's messy because one of the things I saw was a big increase in butarate production from the change in the microbiome, presumably. Well, as we discussed earlier, butarates actually associated with like positive outcomes in terms of insulin sensitivity, inflammation and some other things. So I just, I want to be real cautious before people say, well, there's a change in the microbiome. It must be a bad change. We don't know. It's possible. And again, if we have, you know, 10 more studies come out and start to show this, then I will start to shift my personal opinion of artificial sweeteners. So in anticipation of sitting down today, I did solicit for questions on social media. And one of the questions that got a lot of upvotes, likes if you will, was it one that I think raises interesting questions about short-term and long-term health and it's the following. I think it's a common scenario. A number of people want to know, what is the healthiest way to approach a kind of rapid weight loss? And here what I think is happening is somebody has an event coming up or they're just tired of being the way they are carrying the amount of out-of-post-issue they are. And they wanted to know whether or not it is safe to, for instance, lose three pounds a week for a few weeks in anticipation of a wedding or some other event. And whether or not straight-chloric restriction and increasing activity is the best way to approach that. With the understanding that they may gain back a little afterwards, they might make, I think ideally, they'd like to maintain it afterwards. But what do you think of that sort of approach? You know, cutting, you're, cleric can take in half, for instance, and then doubling and also doubling your physical output. So it's interesting because the, you might be surprised by what I'm going to say, which is the research data actually tends to suggest that people who are obese, who lose a lot more weight early, are more likely to keep it off. Which seems a little bit kind of contradictory, right? Like, well, that doesn't seem very sustainable. But again, you're weighing competing things. So there's sustainability aspect within. There's also, like, buy-in is huge for sustainability, right? So for a lot of overweight obese people, if they started diet and they don't see something quickly, they kind of bail on it because it's, you know, it's not working. Whereas if they see some rapid results pretty quickly, they buy-in even harder, right? And so I think the conversation, especially for if there's any coaches or trainers out there, is just presenting that as the, you know, one of my favorite lines is there are no solutions. There's only trade-offs. I think Thomas Solse of that. So you're having a trade-off here. It is, yes, you're going to lose fat faster. You might lose lean mass a little bit faster too, which can be a problem. But I will say the more adipose tissue you have, the more aggressively you can diet without negative consequences. Somebody like me doing a really aggressive diet is not going to be good for my lean mass. Then I have a higher lean mass than normal, too, I have a lower body fat than normal. As your body fat goes down, the percentage of weight loss from lean mass goes up. So people who are very obese, because they have so much adipose tissue to pull from, there's very little reason for the body to catabolize lean tissue. Now that being said, if you go on a, people misinterpret, like, they're like, well, I got a body in body done, or a dexadund, and I've lost, you know, two pounds of lean mass, and they've lost 20 pounds overall. Well, keep in mind, adipose tissue itself is 13% lean mass. So there's actually like, you know, protein component to like the structural component of the adipose tissue, and it does have some water. So it's about 87% lipid, but the other part is lean. So at minimum, you should expect a 13% reduction in lean mass when you diet. And then when you consider like you lose body water overall, which is registers as lean mass, and you lose, your spanked tissues can shrink a little bit. So it's normal to lose, you know, for the average person to lose like 25 or 30% of the weight that they lose from lean mass, but that doesn't mean skeletal muscle tissue. And again, the more adipose you have, the more aggressively you can approach the diet without really negative long-term consequences, two lean mass or your overall health. But balance that with, okay, if I'm going to do this, I need to understand that I'm not going to be dieting this way forever. I'm doing this to give myself a boost to the beginning, and I have to be okay at some point with transitioning to something that's a little more sustainable. Based on what you just said, it reminds me of the satiety signal effect of exercise you mentioned earlier that exercising can improve our sense of when we've had enough to eat. I just want to briefly mention that when Ali Krum was on the podcast, she mentioned that they'd been doing a study that I have to pair you to and have here the conversation as a fly on the wall because what she was telling me was that if people believe that a food is nutritious for them, then eating less of it registers as more satiating. Whereas if people view dieting as a deprivation system, like, oh, dieting is hard and the food sucks and it's terrible. Well then, they crave all sorts of other things. Whereas they actually observe in their studies where people report reduced craving if they are told, for instance, a chicken breast and broccoli and some olive oil and rice is actually quite nourishing. It's actually really good for you. Then people eat that and they feel like they've actually eaten more. The satiety signaling goes up. It's just a point that Ali made of those aren't my data. The satiety is so impressive because even the rate at which you eat and write down to the size of the plate and the color of the plate, like the contrast and color, really. They see, I can't remember exactly. I think it's if the plate is a similar color to the food, I think people eat more. Whereas if it's a bigger contrast, they eat less. But even like, plate color can make a difference on how much you eat. So, again, human brain, very amazing, but also very dumb in some ways, right? Not an optimized algorithm. I always joke with people. I'm like, just look at how stupid humans are. You put some water in front of them, like, the ocean. They're like, oh, yeah, I'll pay 10 times more for this. But it's just, we're kind of wired that way. The reward signaling pathways in the brain run one chemical mainly dopamine. There are others, of course, but and very few algorithms. It's sort of like an intermittent reinforcement is one, random reinforcement, but in the end, there aren't many algorithms. And we are probably not optimized, certainly not optimized for our own health because people will eat themselves to death, drug themselves to death, etc. Simply because something felt good at one point. It proves your point. One of the things I tell people, I said this on Andy Fosolos podcast was, interestingly, the dichotomy of life is, if you do what's easy in the short term, your life will be hard. If you do what's hard in the short term, your life will get easier. It's very strange. It actually ethnsucleic had a great example of this. When he was over 500 pounds, he said, the amount of work I had to do to construct my life that I could just live was so much more work than just going to the gym for a couple hours a day. He's like, the gym work is hard. He's like, but when I look back at how much work I had to do to sustain that lifestyle versus just going to the gym and restricting calories, he's like, to maintain the lifestyle of being 500 pounds was infinitely more difficult than what I do now. And so again, a great example. Short term hard, going to the gym, calorie restriction, long term, life's easier. It's really interesting dichotomy, I think about a lot. I can't be restated often enough. Seed oils. People want to ask about seed oils. And for those of you that are listening who are wondering why we're sort of chuckling already, as you mentioned, that both in the Twitter sphere and Instagram and online, there's these very polarized views that probably aren't worth focusing on for too long, but there are a number of folks out there who are arguing that seed oils are the source of all, you know, the obesity epidemic, inflammation, et cetera, illuminating everything. And then there are those that would argue just the opposite that, you know, meat is the source of all problems, et cetera. And I think we've thanks to your nuance and expertise. We've hopefully appropriately framed things that it's never that black and white. It's simply not. Orally, rarely. I love olive oil. I realize that doesn't fit exactly into the seed oil category. I love olive oil. I use it in moderation. I do also consume some butter in moderation, et cetera. But are there any data on seed oils? And here, a good example, I think would be like canola oil, which comes from the rape seed that literally was renamed canola oil because rape seed oil is not good marketing. No, no, exactly. So the first thing I'll say is seed oils have negatively contributed to our overall health because people in the last, you know, 20, 30 years, what they have tend to add to add into their diet that has increased the overall calorie load is oil. Like these various mostly from seed oils. But when we look at like one to one replacement with other fats. And so I, if you look at the epidemiology, yeah, you can find some epidemiology showing people who consume more seed oil have more negative health outcomes. Problem is again, tied up with a multitude of other behaviors. And then you can find mechanisms and the idea is, well, these have, they're polyunsaturated, which means in the fatty acid chain, there's multiple double bonds, which those double bonds can be oxidized when they're exposed to heat and some other things. And so the idea is, well, when you cook with these things and, you know, they get, they get, they get, they make it oxidized and that's going to cause inflammation in your body. So that's a plausible mechanism. So as always, I defer to the human randomized control trials. And so what you tend to find is when you substitute polyunsaturated fats, or sorry, when you substitute saturated fats for polyunsaturated fats, it's either neutral or positive in terms of the effects on like inflammation is basically neutral. There's some studies that show a positive effect of doing polyunsaturated fats, but it probably depends on the individual polyunsaturated fat. And that's the other thing I don't really, is difficult because you're categorizing like everything in this one bucket and there are some differences between individual fatty acids. Even with saturated fat, like for example, a steric acid doesn't tend to raise LDL cholesterol, whereas you know saturated fat as a whole tends to raise LDL cholesterol, but there are some saturated fats that don't. So again, it's like we're putting things in buckets and it's a little more nuanced than that. Even if you look at like the effects of polyunsaturated fats on markers of cardiovascular disease, again, tends to either be a neutral or positive effect when you substitute saturated fat for polyunsaturated fat. Now if you want to get into like monounsaturated versus polyunsaturated, there's some, there's quite a bit of disagreement between the studies. What I would say based on the human randomized control trials is that you're probably better off consuming monounsaturated and polyunsaturated in place of saturated fat. But again, if the idea is well, that means polyunsaturated are good for me. So I'm just going to dump a bunch of oil on everything and now you're upping your calories. Well, that's a negative now, right? Because you have to do with the bigger problem of overall energy toxicity. So I'm not somebody who likes to demonize individual nutrients. I just haven't seen really compelling evidence that seed oils are the root cause of the problems that are being suggested. And I think this is a good example of kind of like whenever there's something that pops up in the fitness industry, there's always like the opposite thing that pops up and it's like the reactionary, you know, extreme reaction to whatever this thing was over here. And I think that's what we're seeing with some of the the seed oil stuff is it's mostly people who are trying to kind of expose the virtues of saturated fat. And listen, I think it's fine to consume some saturated fat. But again, you know, I think limiting it to, you know, seven to 10% of your daily calorie intake is probably wise. Again, based on the all the consensus of the evidence I've seen. And so once again, like we're struggling with this, okay, we've got this epidemiology and these mechanisms that sound good. But then what actually happens when we we do some human randomized control trials and so far I just haven't seen the evidence to suggest that seed oils are independently bad for you, independently calories they contain. You said the words overall energy toxicity and I just want to highlight that I think that's a fabulous term. I don't I don't think enough people think about that because they they are primed or we are all primed to think, okay, seed oils might be bad or artificial sweeteners might be bad or this particular component of blood work might represent something good or bad without taking into account overall energy toxicity of the toxicity of over consuming calories energy. And thank you for pointing out that most of the data point to the fact that saturated fat should make up about no more than seven to 10% of total daily, chloric intake. Is there a lower end threshold that can be problematic? Over instance, I've noticed that my blood profiles, especially in terms of hormones improve when I'm getting sufficient saturated fat. Maybe I'm a mutant, but years ago because I'm a product of growing up in the 90s I tried a low fat diet. I it certainly crushed my androgen levels. I started adding some butter back in and I was right back in the in the in the sweet zone where I wanted to be. So you know, seven to 10% of totally daily, chloric intake is I'm guessing is probably about what I do now. I'll have to check. But is there a danger to going too low in saturated fat? So again, no solutions, only tradeoffs, right? What maximizes out testosterone might not be the best thing for longevity, right? And vice versa. Now I'm not I'm not making that claim specifically, but I think it's important to understand this that I think we all have this idea that there's just one iconic diet out there that is going to be the best diet for building muscle and burning fat and preventing cancer and heart disease and the reality is like there's overall healthy dietary patterns that we see that are good for those things. But when we get down into the weeds, there's probably some push and pull here as well, right? So when it comes to saturated fat, there is some evidence that if you're too low on it, that yes, you can have a reduction in testosterone. Now is that reduction in testosterone? Let's say 15, 20% whatever it may be, is that sufficient to actually cause loss of lean mass that we don't know? That's never been shown. Interestingly, I just remembered this. There was one study that was comparing polyunsaturated fat versus saturated fat and they equated total fat. And one of the really interesting things was the group getting the polyunsaturated fat had more lean mass at the end of the study compared to the group getting saturated fat. Now, so only one study I've never seen this replicated. So I'm very... This is a situation where I say I would like to find out what the mechanism of that is because this could just be random. But if that gets shown over and over, what I might say is, okay, well, what's the... What do we... If polyunsaturated are somehow increasing lean mass compared to saturated fat, who cares when I was with testosterone, unless that reduction in testosterone is causing some kind of impotence for your life, right? So all that to say, I don't really know. And by the way, that's something for those watching and listening, real experts every once in a while you should hear them say the following words. I don't know. Exactly. My graduate advisor was exceptional at that and she was brilliant, right? And then in terms of cholesterol synthesis, you really need a very, very small amount of saturated fat for LDL cholesterol synthesis. Your liver can synthesize. Like the amount of LDL cholesterol or cholesterol that your body requires is so small in terms of just living and being healthy. So I don't think you need to worry about that. And from a cardiovascular disease standpoint, there is some evidence that even taking people who have like quote unquote low LDL of like 80 or 90 and taking them down to like 30 or 40, that there is still a benefit for the risk of cardiovascular disease. So again, you're weighing these two buckets, right? So what I say, if you're doing 17% from saturated fat, you're probably fine. Received a lot of questions about whether or not there are female specific diet and exercise protocols. I realize this is a vast landscape, but some of those questions related to menopause and premenopause and some related to the menstrual cycle, most related to variations across the menstrual cycle. In terms of let's just say diet, maintenance or subchloric diet, are there any things that you've observed? We'll talk a little bit later about this wonderful app that you've produced this carbon app, which helps people manage their energy and take and a number of other things. And so there you have a sort of a database or at least an experience base. And then I'm guessing there are probably also studies exploring male versus female differences in terms of adherence and what sorts of diets were. Are there any general themes that one can extract from that? That's going to be really unpopular segment for the women. It doesn't seem to make a big difference. Well, they may be relieved to hear that because it would make sorting through the information space and certainly the information we've covered in this podcast up until now, simpler. It means that everything isn't different for them. Yeah. So, if you look at the male versus female studies relation to diet, they seem to respond to similar way. Like similar calorie deficit, teams to produce similar results. If you do low carb, high carb, regardless, it seems to boil down to the same principles. Now, training wise, we do know that female, like the muscle fibers adapt a little bit differently to training, but without getting too far into the weeds, it doesn't really change the way you should train. Because for the most part, building muscle, there's a lot of different ways to build muscle. So we know that like light loads up to maybe like 30 reps, as long as it's taken close to failure, have basically the same effect on building muscle, at least in the short term, as heavy loads for low reps. It's mostly about taking the muscle close to fatigue or failure. You don't have to go too failure, but getting close within a few reps, if you're between one rep and 30 reps, if you're getting close to failure, seem to produce similar results. So, again, great. You can pick whichever form of discomfort you prefer. When it comes to female specific training, again, females actually, this is one thing that a lot of people don't know. They actually put on a similar amount of lean mass as a percentage of their starting lean mass as men. In fact, there's no statistically significant difference in the amount of lean mass they put on. Now, the absolute amount of lean mass that's added will be greater for men because they started with a greater amount of lean mass. But the relative increase in lean mass is pretty much the same from similar training. Now, there's some differences in fiber types. Females tend to be a little bit less fatigable than men. They can go a little bit harder a little bit longer. There's also some evidence that they recover a little bit better, but that also could be simply due to the fact that they're not able to use as heavy of loads to induce hypertrophy so I kind of have this theory that while as a percentage of your 1 rep max, you can program things, I think absolute load matters. When you look at the most elite power lifters, the super heavy weights aren't squatting three or four times a week because they're squatting eight, 900 pounds. I think that there's an overall recovery effect there. Again, I've no data to back this up. This is just my observation. When you get into the lighter weight classes, and this goes for men too, you do see quite a few people who do many training sessions at high RPEs and seem to be able to recover from that. I do think the absolute load makes a difference. Now, when it comes to menstrual cycle, this is one of those things where I kind of tell people, do what you prefer. There's some people who have said you should program, you should kind of schedule your training around your menstrual cycle, which is whenever you're going through your menstrual cycle, reduce the intensity, reduce the volume because you're not going to feel as good, you're not going to train as well. What I would say is just auto-regulate that. If you go in and you're on your period, but you feel good and you're doing well that day, then I don't think you necessarily need to back it off. There was one study that kind of supported that notion. If you go in and you feel terrible and you feel like you could use a reduction in intensity and volume, then it's totally fine to auto-regulate that. When I say auto-regulation, auto-regulation means you are regulating the individual training session based on your performance. I auto-regulate in so far as I'm a super nerd, so I have a velocity device so I can actually attach to the bar and see how fast the load moves and I know it varies different warm-up weights, what velocities I should be hitting. If I hit my last warm-up and my velocity is about 10% higher than usual, I can be pretty confident that that's going to be a good day for me. If it's lower, then I can back it off a little bit. In fact, at Worlds, when I hit my last deadlift, my last deadlift warm-up, it was 30% faster than I usually hit in the gym. I turned it looked at my coach and I said, yeah, we're going to get this today. There's various forms of ways to auto-regulate, but again, women, if you're on your period, but you feel good, I don't think there's any reason you need to back off, but if you're not feeling good, then it's totally appropriate to back off. Raw versus cooked foods. People wanted to know whether or not, for instance, eating a raw apple versus, I don't know, does anyone cook apples? People used to bake. Like, apples was a dessert when I was a kid. It was kind of the let down dessert. Sorry. It was kind of like not awesome unless it had a scoop of ice cream in it. Even then, maybe not awesome. Anyway, raw versus cooked, obviously, if you burn a piece of meat to the point where it's pure charcoal, that's too much. If you eat, there is a small movement surrounding eating raw meats. That's not something I particularly enjoy. Frankly, sushi is the only raw food I personally ingest. I am very careful about the sourcing, rightly. Reputable places. Is there anything real about this in terms of being able to extract the amino acids, vitamins, and minerals from the food raw versus cooked? It just looks cool for Instagram. When you cook foods, they actually tend to become, in terms of protein and containing foods, they tend to become more digestible, not less. Eggs are this way, meat's are this way. Also, when you heat protein, you denature it. I think they hear that word denature and they think destroy. That is not what denature means. Proteins fold up into 3D dimensional structures. You know this, of course, based on their amino acid sequence and their specific energies of those amino acids. When you heat protein or add acid, it starts to unfold that protein structure. That happens during digestion anyway. I always chuckle when I've seen some companies come out with a way that you can cook with. That's not going to destroy the amino acids. I'm like, so you mean like regular way. Cooking typically cooking actually makes amino acids more bioavailable, not less. I would stay away from charring your meat because there is some evidence that charring creates polyamatic hydrocarbons, which at least in animals, when they give those, they appear to be carcinogenic. If you do charring meat by accident, I would just cut off the charred portions and then you should be fine. The charred is delicious. Not if it's charred too much, but there is something about a charred cross-thronomy. My dad's Argentine and I like that. What about people referred to them in their questions as carb blockers, but I think what they're referring to are things like burberine and some of the glucose scavengers. One glucose scavenger I'd love for you to comment on is this assertion that taking a brisk walk after a meal or maybe even a slow walk after a meal, some movement can help downshift the amount of circulating glucose in some way. I've heard that not a lot of people, but some are starting to pay attention to this idea of taking things like burberine or even metformin can scavenge glucose. I personally can't take burberine if I take it, I get massive headaches unless I've ingested tons of sugar in carbohydrates. I just don't mess around with it, but I know there are a number of people out there that want to know whether or not these glucose scavengers can be useful. I think that is really majoring in the miners of being honest. As far as the carb blockers, there's some white kidney bean extract and those sorts of things. They do block the digestion of carbohydrate, some. When I say block, those watching or listening, metabolism is typically not on and off switches. When we say things like block or attenuate or inhibit, typically we're not talking about just a switch on the wall that you press it and everything turns off, we're talking about a dimmer switch. It just changes the emphasis. These carb blockers can reduce the absorption of carbohydrate. They don't seem to cause weight loss when you just do it in normal diet. Now, why is that? All it does is once those carbohydrates get to the large intestine and your bacteria get a hold of them, they start fermenting them to volatile fatty acids, which could reabsorb into your liver. You don't get the increase in blood glucose, but you still get almost all the calories from it because it's just in a different form. If carb blockers, if they actually worked really well, if you block something from being absorbed, your GI typically does not just let undigested material sit in there, you get diarrhea. That would be the outcome. It's also how I debunked the whole 30 grams of protein at a meal. You can't absorb any more than that. If that was the case, when you ate a steak, you would just start having diarrhea every time you went over that 30-gram threshold. I remember during college, so this would be early 90s, there was the olesstra craze. This idea of putting in non-digestible thing into things like potato chips so that it would clear through the GI tract faster, not absorb as many calories. It does raise, this went nowhere, obviously. You don't hear about this anymore, but it does raise an interesting question related to energy balance, which is gastric emptying time. Obviously, in the landscape of eating disorders, in particular, anorexia, use of abuse of laxatives as a way in which people will, in an unhealthy way, try and control their weight. There's a lot of problems with that approach. What about gastric emptying time? Is this one way that people could control their energy balance in a healthy way? Where does fiber come into play? fiber tends to improve GI transit time because it adds bulk. Your GI system is basically a tube, and it has peristalsis, which is wave-like contractions that moves the food down to the tube. Well, if you have more bulk to the food, like with fiber, you can move it through a little bit better. Now, in the gastric, the stomach, specifically, fiber tends to delay gastric emptying and slow it a bit, probably because it congeals a little bit. Now this kind of gets into the glycemic index argument. If you do low GI foods, you'll have a slower release of glucose. It's a slower gastric emptying time. Does that affect energy balance? There are quite a few studies looking at low GI versus high GI foods. In the studies where they don't control calories, low GI tends to outperform high GI, but when they control calories, there's no difference. With that, what I think that suggests is low GI foods just by their nature tend to be higher in fiber. I think it just kind of comes back to the fiber issue. Got it. I like to ask you about supplements for a moment. It's an enormous landscape, but I believe there are a few things that you believe in, meaning they exist and there are decent data to support their use. Maybe even some anecdotal data based on your own experience, as long as we highlight it as such, it could be interesting. I've heard you talk about two in particular, one that I'm very familiar with, which is creatine monohydrate. You share your thoughts on that, not just for muscle building, but maybe any other purposes for it. The other one is one that, frankly, I'm learning more about all the time now, thanks to your prompt, which is Rydolia Roséa. I think I pronounced that correctly. Why that might be interesting or of use to people. Yeah. Touching on creatine, it is the most tested, safe, and effective support supplement we have. There are thousands of studies on creatine monohydrate now. I would say very clearly, too, if you're using any other form of creatine, I think you're wasting your money. Protein hydrochloride has some hype around it. It's apparently a little more soluble. The claim is that you need less, but there's only a couple studies on it, and it's more expensive. And creatine monohydrate is not particularly expensive. No, I realize people have different budgets, but it doesn't land in this. It's not a budget breaker. Yeah, it's gotten more expensive because of COVID and supply chain issues. Even the, there's forms of creatine that appear to be as good like hydrochloride, but it's more expensive. And then things like creatine ethyl ester has been shown to be worse than creatine monohydrate. Buffered creatine is as good or worse, and it's much more expensive. So I tell people, just take creatine monohydrate. It is tried and true. It's been shown to saturate the muscle cells 100% with phosphocreatine, and that's what you want. So creatine works through a few different methodologies, one through increasing phosphocreatine content, which helps improve exercise performance. It also appears to improve recovery, and it increases lean mass, a lot of which is through bringing water into the muscle cells, but that is, I mean, muscle cells are mostly water. So when people say, well, it's just water, that's what muscle cells mostly are. And it also increases strength and some other metrics. Now it also has been shown in studies that people tend to get a decrease in body fat percentage. Now that's probably because they're getting an increase in lean mass, and so the relative is a decrease in body fat percentage. But there are a few studies to show a decrease in fat mass as well. I don't think the creatine's a fat burner. I think that people are able to train harder, build more lean tissue, and so that's probably having an effect on fat mass. Then they've actually shown more recently some cognitive benefits to creatine, which I find really interesting as well. But they only knock on creatine that anybody's been able to come up with because they've debunked the kidney stuff, they've debunked the liver study. There's no evidence that a harm's healthy kidney or liver is hair loss. So what about hair loss? Because there was one study in 2009 that showed the creatine increased DHT. But they didn't really show an effect on any other sex hormone. So it's kind of strange. You would think if there was an increase in DHT, there would be something else that changes as well. And it's only one study. And again, didn't directly measure hair loss, measured DHT, which we know is involved in the loss of the follicle. So what I would say is that I am not convinced. It's only one study never been replicated to my knowledge. And it was looking at a mechanism rather than an outcome. So if you're somebody who's prone to hair loss and you want to avoid creatine because of that, I understand. But for most people, I don't think it's something to worry about. Do you emphasize the classic loading of creatine taking it a bunch of times per day and then backing off or just taking it consistently at the, I think, five grams per day is kind of a typical dose that people take? So again, no solutions, only trade-offs. You can load it and you will saturate your phosphocreatin stores faster, like you do within a week. If you just take five grams per day, it'll take two, three, four weeks. But you will get to the same place. And you're probably going to have a much lower risk of GI issues. Some people, creatine can be a gut irritant. If it is for some folks, I would recommend splitting it into multiple doses. So maybe like multiple two, one or two gram doses per day. And definitely don't load it if you're somebody who has GI issues from it. As far as Rodila Rosea, the research is still in its infancy. I was just reading a new systematic review that kind of concluded that we need more high quality research. But the research that is out there seems to suggest that not only does it reduce physical fatigue, but it also reduces the perception of fatigue and may also enhance memory and cognition as well. And it's referred to as an adaptogen. So I really like it. My anecdotal experience is when I combine that with caffeine, it tends to kind of smooth out the effects of caffeine. It's a more pleasant experience. And there's also some evidence that if you're like coming off caffeine, that it can reduce the negative side effects to caffeine withdrawal. Which by the way, I didn't really believe in that until I actually did a cold turkey. So before I meet, I will cut out caffeine for seven days because you can basically reset your caffeine tolerance in seven days. And like two days in, I mean, I'm a groggy. I've got the headaches. Usually I'll get like body aches that come up because caffeine is actually a mild anal gizook. And yeah, so it's very interesting to say, but I slept like a baby. I'll tell you that. And then we'll go back to the caffeine prior to your event. To the meat. So you really want the maximum punch from it. That's why you do that. And like I said, Rodeola tends to, it doesn't eliminate those negative effects, but they tend to, it tends to dampen them a little bit. So I really like it. Again, would like to see more research on it. But there's a lot more stuff coming out like Ashwagandas, another thing that looks pretty promising. Seems to increase testosterone modestly. I don't think it's like they've shown increases in lean mass. I don't think the increase in testosterone explains the increase in lean mass. It's just not a big enough increase. Could it be the decrease in cortisol? People have talked about it. It's possible. It does decrease stress, stress hormones. It also has been shown to help with sleep. But I would like to see more research looking at mechanistically how it's increasing lean mass before I kind of say conclusively that this is the next creatin. There's more research that needs to come out. And then there's some other things that have an effect. Citrulein malight. There was a new meta-analysis that showed that citrulein malight can reduce fatigue and increase time to fatigue. And it may actually have some small recovery benefits as well. Different forms of carnitine can actually have recovery benefits. And actually interesting. I think it's carnitine tartrate actually has been shown. Volic published a study that actually showed that increased angiogen receptor density in muscle cells. That's interesting. No. And then there are other forms that are pretty, I think there's good evidence that they can improve sperm and egg health for people who are looking to conceive. Interesting. Yeah. They're surprising number of studies on this in humans. But yeah, angiogen receptor density. That's from oral alcharnitine. People are taking castles, not injecting directly into muscle. And then you've got things like obviously like the other most effective supplement out there is probably caffeine. I mean, like if you look at the research studies, caffeine produces very consistently. Improvements in performance. So that's another one. Some people don't like the effect of caffeine. That's okay. But I wouldn't know because I'd never come off it. Exactly. Exactly. Well, interestingly, they do show that the effect appears to be consistent. That even if you're a habitual caffeine user, you do still get a benefit every time you take it. But like you said, you're just used to it. So there's those things. And you've got things like beta alanine, which for it's in our pre-workout, probably not super helpful for most people for resistance training. It does seem to have some benefits for high intensity. If you get out more than 45 seconds or 60 seconds of really hard training, it does appear to help with delaying fatigue for that. And then you've got things like b-tain, or also called trimethylglycine, which there's some evidence that can improve lean mass. There's some evidence that it can improve power output. So there's a few things out there. But most of the stuff is not very good. So I think that those kinds of supplements, very useful. But again, I would never tell people they need supplements. Like again, even like something like Crippton is going to be a very small effect compared to proper nutrition, recovery, and hard training. One of the things I was talking about, I was talking about Ben Bruno the other day. And I said, you know, some people will ask me, how does this person make progress because they're programming as not evidence-based? Or this guy, how's he, his exercises are dumb? And I'll say, yeah, but they train really hard for 20 years. One commonality you see between like really successful athletes or bodybuilders is they train really hard. And one of the things I have observed is the more into the weeds, people tend to get, and again, this is just my own anecdote and observation. The more into the weeds they tend to get, the less hard I see them train. And so one of the things I really like that Mike Israel told said, who's got a PhD and is a bodybuilder himself, he said, you can't outscience hard training that if you're looking to build muscle and you're looking to improve your body composition, the main thing is just doing the work over time. That sounds easy and the hard work. And I would add to that, and this is true of academic endeavors, too, of course, I think I hope you'll agree. Absolutely. Which is that, yeah, you know, the other thing is given the mental side earlier, we were talking about how satiety signals in the brain and what you think about foods can be relevant. Learning to really enjoy training hard, in addition to learning to really enjoy eating well, not just for the effects that it has on body composition, composition, excuse me, those two, of course, but just learning to really enjoy the process of training hard and a really hard workout or really hard paper that you have to sort through or really digging through a book that's challenging. Learning to really enjoy that, I think, is a, if there is a power tool out there, it's the psychological end. And I think a lot of that is getting the confidence of doing something hard that there's a payoff at the end, you know, and a lot of people, I get asked a lot in my Q&A, how do I get more confident? How do I become more confident? I'll tell people you have to do. You have, there's no hack you can't read about, you got to get in the arena and I don't mean like compete in sports necessarily, but like doing a PhD or doing something, just something hard where you're putting yourself out there and you're saying, this is my goal and I'm going to go for it. You just learn so much by doing that about yourself. And so just what you said, I will reframe things in my mind when bad things happen from, it's not to say I never get stressed out because I do and it's not to say that I never get down because I do because I'm a human. But when something bad happens, I should post about this in my store today, when something bad happens, I very rarely anymore do I go, well, what was me, why did this happen to me because you're in the universe, random bad things are going to happen. So instead I say, if I'm not dead, instead I say, well, what an exciting opportunity to overcome an obstacle and I bet because in the experience of my life, the biggest lessons and the best things in my life have actually come out of the most challenging, worst things that have happened. And so again, I would never have been able to do these sorts of things if I hadn't taken up weightlifting because weightlifting taught me so much about perseverance, delayed gratification, overcoming obstacles. And that's why I love it even to this day. And I'll still get butterflies when I go in for a squat session, even though I've been doing it for 23 years. That's wonderful. Well, it's clear that you embrace hard things and I, for people listening to this, obviously, it doesn't have to be weightlifting, thinking hard things, learning an instrument, learning a language. Challenge is an absolute builder. And they've actually shown those sorts of things like when you challenge yourself and also mentally that I think there was a new study that came out basically showing a reduction in the risk of Alzheimer's and other age-related cognitive decline. I mean, basically use it or lose it, right? Yeah, the desire and the will to persevere, no doubt translates to this thing that we call the will to live, right? It's related to the will to live. Well, I think that what you just said, beautifully embodies what most people are aspiring to, which is to, I think most people actually want to do hard things. They don't just want to have the results. I think that most people deep down understand some understanding that their reward system works that way. I must say, this conversation for me has been tremendously rewarding. First of all, it allowed me to meet you in person for the first time, which I've really enjoyed. I'm certain this won't be our last interaction on this podcast and elsewhere. Also, the amount of knowledge that you contain inside you is astonishing. There's a lot of stuff right around up there. And we all benefit because your ability to pull from the mechanistic side. Again, I think in not limited to, but related to your background in biochemistry all the way through to the impact in humans, animal studies, being able to understand where those sit relative to one another. And then you're obviously a practitioner of you practice what you preach and what you talk about pertains to men, to women, younger people, older people, people who are vegan, keto, carnivore. You really are able to net a tremendous number of ideas while staying really nuanced. And data driven. And so I just want to say for myself, and on behalf of the listeners, really appreciate you coming in here today and sharing with us your knowledge, we will absolutely point people in the direction of where they can learn more about you. And one of the places that I definitely want to mention before we part, however, is this carbon app. And I should just mention, this isn't a paid promotion or anything of that sort. Actually, one of our podcast team members has been using carbon for a long time. This is an app that you've devised, which allows people to navigate the exercise nutrition and energy balance space for weight loss, muscle gain, fat loss, weight maintenance. I would just like to briefly ask you about that before we conclude. Without necessarily telling us everything that's in the carbon app, I'd love to know, what are the major things that it does and is good for? And then what were some of the key things that you wanted to make sure we're in there when you built it? Like, what's the sort of logical backbone behind it? Because I think there are a lot of food counting, calorie counting, exercise apps out there. Everyone I've talked to that uses carbon, including our mutual friends, Sagar and Gettie, this member of my podcast, etc. Raves about it. So what is carbon and what does it do and what was your mindset in building it? What did you really want to see there that you didn't see elsewhere? So those things may not know, but I really, I started online coaching people for nutrition back in 2005. And that was the vast majority of my business all the way up until like 2017. And I had a lot of success with that, whether it be just average folks looking to lose weight or build muscle and right up to elite level competitors and physique sport. So I kind of had this idea like, I don't want to say I had the idea. A few people had the idea. What if we could take what I do in coaching and try to automate as much of that as possible? Because you know, by the time I was becoming a really popular coach, I mean, I was expensive. You know, you were looking at like, you know, me charging, I got to the point where I was charging about a thousand dollars a month for coaching, right? And not most people cannot afford that. And I would like to not just coach rich people. You know what I mean? I would like to be able to help other people. So the idea was to create an app that could do some of this stuff. Now, there's always a place for human interaction. But for people who can't afford that, our app is basically 10 bucks a month. And basically what we wanted to do was set up an app where think about if you went to an nutrition coach, what would they do? They would probably ask you some questions about your goals, take some anthropometrics, and then they would use like that, maybe dietary preference. And they'd use that information to kind of formulate a baseline plan. That's what carbon does. So we ask you, I think there's eight questions in the sign up flow about like your activity, your exercise, your lifestyle, your body weight, your body fat percentage. And if you don't know it, we help you calculate it. It's not perfect, but it's better than nothing. And then your dietary preferences. And we use that to come up with kind of your baseline. And your baseline will be your calories, your protein, your carbohydrates, and fats. And what's different about our app, because like apps like my fitness power, we'll do that as well. What's different about ours is we encourage people to log their weight daily for the reasons that we talked about earlier. And then you can also track your food in the app. And honestly, I think our food tracker is actually like way easier to use than most of them out there are. What we typically get great, rave reviews about is how user-friendly our interface is. That it makes intuitive sense. And so you track your food, try to hit these macros that you're prescribed. And each week you will be prompted to check in with the coach on your check end day. And then you put in some information, and then based on how you're progressing, the app will adjust or not adjust based on how you're progressing. So for example, if you're hitting a weight loss plateau, it will sense that, and it will reduce your calories, or if you're trying to gain weight and you're hit a plateau and increase your calories. And there's a lot of back end algorithm stuff that takes care of this. But the fundamental crux of the app is we try to determine your total daily energy expenditure because that's going to tell us the first big thing we need to know, which is how many calories do you need to be eating for your goal? So on the front end, we basically do our best guess based on your anthropometrics. Not going to be perfect, but it'll give us in the ballpark. And if you do know, like some people already know, well, I know what I maintain my bodyweight on. I guess, but we can manually enter that during the sign-up flow. So that's helpful for people who are super nerds like me. But then if you're just, people will ask, well, do you take Apple Watch data? Do you take this? Do you take that? And no, for the reasons we talked about, it's an overestimates energy expenditure. What our app does is it's an algebra equation. If you, because your bodyweight, your maintenance calories is your total daily energy expenditure. Your average calories that you eat to maintain your bodyweight will be the same as your total daily energy expenditure. So if we know how bodyweight is changing, and we know how many calories the person's consuming, we can actually solve for what energy expenditure is. And you can see in the app that will, there's a maintenance calorie tracker or energy expenditure tracker. And typically, after about three to four weeks, even if the app was off at first, it will have you pretty darn close. Because, like, let's say somebody comes on and their goal is to lose, you know, a pound and a half a week or something like that. And the first week, they lose three pounds. Now the app actually accounts for the fact that you can lose more water weight the first weeks. They probably wouldn't get an adjustment. But let's say the next week, they lose three pounds. The app will sense that and adjust their calories up because it will be estimating that their energy expenditures are actually higher than what it previously estimated based on the amount of weight they're losing. And the same thing goes in reverse. If they're not losing the amount of weight that they're supposed to, it will lower them based on the fact that it may have overestimated their energy expenditure. But that's the first crux of it is tracking that energy expenditure. And then the next thing is protein. So when the back end algorithm stuff is happening, calories are set first based on your energy expenditure and your goal. So for example, if you have an aggressive diet, your calories are going to be lower even if your energy expenditure might be a little bit high. Just because if you're trying to lose two pounds a week, I mean you're going to be in a pretty aggressive calorie deficit. So it's going to set the calories first. Then it will set protein based on your lean body mass. Then the calories that are left over will be allotted to carbohydrate and fat depending on your dietary preference. And we have a few different dietary preferences. It's balanced, which is about 50, 50 to 60, 40 carbohydrate to fat of the remaining calories. Then you have low fat, which is obviously a higher ratio of carbohydrate. You have low carb. You have a ketogenic diet, which is very, very low carb. And then there's also a plant based option. And within each of those options, still you can go in and actually shimmy the macros a little bit within a certain range so that you can kind of dial in what your specific dietary preference is because again, if we go back to what is going to produce the best long term results, it's whatever the person can adhere to. So we really try to start with the concept of adherence by allowing people to have the dietary preference that they want. And there's some other apps out there that are good apps like, for example, we get asked a lot what's the Dirtch Naur app in the Renaissance Periodization app. And they have a great app. But there's this kind of more rigid and it'll say, you know, you're going to eat this many meals and you're going to have these foods at these times. So we're kind of the opposite. We want to give you maximum flexibility. Now for some people, they would prefer the rigid structure at first. But we find that for most people, giving them more flexibility typically improves adherence over the long run. So that's kind of how the app works. And again, like there's multiple different goals. It's not just a weight loss app. There's a maintenance. There's a muscle building. So you've got all kinds of different goals that can be accommodated, different rates of each of those goals. And I mean, I've used the app for over three years now to do my body weight. And I mean, like when I say that it's dialed me in because I'm very regimented with, you know, logging and logging my weight. So what I targeted to weigh in at worlds, I got down to the point one kilogram. So it's pretty cool to be able to like use a tool that I helped develop to actually coach me. So it's a great tool. You know, we did some statistics. We pulled 2,500 members. And one of the questions we asked is, would you recommend this to a friend? And 91% said yes. So we are our average. I think our average retention is like seven months, which for an app that costs $10 a month is really great. So. Yes. I know you use it. This is not a paid promotion. I, but I think people need guidance and tools. And what we know about the human brain is that winging it can work, but that the brain will cheat itself often. There's a fineman quote about this and I'll get it wrong and it's always bad to try and quote fineman anyway, because he said it so much better. But that we are the easiest, you know, it's easy to fool ourselves, basically, is what he was saying. Easy yes to fool ourselves. Absolutely. Great, we will put a link to it so that people can check it out. Again, it sounds like a wonderful tool. And a tool that nets a lot of the principles that sit as major themes for weight loss, weight gain. I would assume directed lean muscle, lean tissue gain is what most people are after. Yeah. And weight maintenance because a number of people would like to just maintain. Listen, I really appreciate your time and all that you're doing. Certainly, your time and energy and knowledge today, but also what you're doing on the very social media channels and just the fact that somebody from the depths of academia is out there sharing so much knowledge across so many domains. You're a gem in this landscape of nutrition and one that people really need to hear from. So thank you so much for your time. Thank you. I appreciate the opportunity. I really enjoyed it. We'll do it again. Thank you for joining me today for my discussion with Dr. Lane Norton. I hope you found it to be as interesting and informative and actionable as I did. If you're learning from and are enjoying this podcast, please subscribe to our YouTube channel. That's a terrific zero cost way to support us. In addition, please subscribe to the podcast on Spotify and Apple. And on both Spotify and Apple, you can leave us up to a five star review. If you have questions or suggestions about topics and guests you'd like me to include on the Huberman Lab podcast, please put those in the comment section on YouTube. I do read all the comments. In addition, please check out the sponsors mentioned at the beginning of today's episode. That's the best way to support this podcast. During today's episode and on many previous episodes of the Huberman Lab podcast, we discussed supplements. While supplements aren't necessary for everybody, many people derived tremendous benefit from them for things like sleep, hormone augmentation, and focus. If you'd like to see the supplements discussed on various episodes of the Huberman Lab podcast, please go to livemomentus.com slash Huberman. We partnered with momentus because they are of extremely high quality. They ship internationally and they formulated supplements in the precise ways that are discussed as optimal to take for various outcomes here on the Huberman Lab podcast. 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So again, that's Huberman Lab on Instagram, Twitter, and Facebook. Thank you once again for joining me for today's discussion with Dr. Lane Norton. If you are interested in some of the resources that he and I discussed, including his carbon app, as well as other resources that he provides, please go to the links in the show note captions. And last, but certainly not least, thank you for your interest in science.