Macronutrients: Sugar Structure and Function

Transcript

Hello and welcome to the Institute of Nutritional Endocrinology. I am Dr. Ritamarie Loscalzo and we are here today to talk about *Macronutrients* and the sub category of *Sugar and the Structure And Function*. Sugar is a hot topic. It is in the news. It is something your clients are going to be asking you all the time about. The kind of things they may be saying to you are, 'I crave sugar'. 'I feel like I need a sugar fix after I eat a meal'. Or 'I heard sugar is bad for me, is all sugar bad for me?' 'Why is sugar bad for me?' 'Does my body need sugar?' And on and on and on.

We are going to clarify sugar today, what it is, what it does in the body, what its structure looks like biochemically, how it works. What are the different types of sugar molecules that you will be looking at, and are there alternatives to sugar? Is there a way for you to have your client enjoy the sweet taste without the negative side effects? Let's begin and find out.

Before we get right into the meat of our conversation, I just want to remind you that everything we share is information, not medical advice. It is not intended to replace the medical advice of a qualified practitioner, not intended as diagnosis, not intended as treatment, and especially if you are working with someone who is on medication or is working with a medical practitioner in some form or other, you need to make sure that they are aware that they need to bounce these ideas off their practitioner before they jump right in and start.

Within the macronutrients module we have been looking at the big guys. The things that the body needs in large amounts. The primary one is water. That's what we need in the largest amount. Then we have our macronutrients fat, protein, and carbohydrates that we derive from the food. Within the structure of carbohydrates we have looked at a number of things so far and now we are going to hone in and go deep on the concept of sugar.

Let's review. We have looked at this in the main carbohydrate module but I know that it requires a little bit more detail and reminders. We all need reminders. So review. Sugar on a molecular level. There are three types of sugars that we look at, monosaccharides, disaccharides, oligosaccharides. Monosaccharides composed of one basic core sugar molecule, one glucose or fructose or galactose and we will look at those.

Disaccharides contain two bonded together and there is a bond between them that needs to be broken down enzymatically in the body to monosaccharides. Then oligosaccharides, which are short chains usually anywhere from 3 to 9 sugar molecules bonded together. We will look again at those in more detail. The other type of carbohydrates that we looked at was the polysaccharides, which are long, long, chains which are mostly your starches.

Why do we need sugar? Sugar is at the core of energy production. Each and every mitochondria in the body takes in sugar, glucose generally, and converts it into ATP. So it's really the energy requirements that we have in the body. Where does it come from in the diet? For some people it comes from processed sugar, table sugar which is also usually called sucrose, it comes from processed foods, candies, cakes, pies, etc., it comes from fruit, and it can come from some grains. What affects the rate of absorption and uptake into cells? We will go into more detail about this, but the presence of fiber and fat and protein along with the sugar determines how quickly it is going to get into the cells, and also the type of sugar that it is and where it's coming from. It relies somewhat on the person digestive capabilities.

How is sugar converted into energy? Pop goes the weasel. It goes into the cell, into the mitochondria. First it has to go from the mouth and down into the digestive tract. It has to be broken down into its single monosaccharides. It gets absorbed through the lining of the gut. Once it is inside the bloodstream it has to attach onto the insulin, which is the hormone that helps it to transport across cell walls. It gets into the cell and transported into the mitochondria. In the mitochondria it is combined with oxygen and a bunch of nutrients in what's called the Krebs cycle, which we studied. It gets converted into energy in the form of ATP. That is a little bit of a nutshell about that.

What is needed for sugar to be efficiently utilized? In order to go through the Krebs cycle we need to have a good supply of oxygen. Somebody who has breathing problems, lung problems, is very acid rather than alkaline, has shortness of breath, and they are not going to have as much of the blood saturated with oxygen; that is going to affect it. We also need to dump a number of amino acids to get to the Krebs cycle, and B vitamins and minerals. For a review of that I recommend that you go to the *Cellular Metabolism* Module and really hone in and learn that.

The negative effects of simple sugars; we are going to go into a lot more detail here. The negative effects of simple sugars are number one: they cause a decrease in immune response. In other words what they will do is cause a decrease in macrophages, which are white blood cells that help counteract disease.

They instigate or accelerate, let's just say, the rate of growth of cancer because cancer cells have a lot of glucose receptors and a lot of insulin receptors on them so it's much easier to get sugars into the cancer cells than it is to get into the good cells. Dental decay, throwing off the acid alkaline balance, and a number of other things. [6:36] What are alternatives to sugar for satisfying the sweet tooth? We will go through a number of those. [6:44] Let's just look at the molecular level of sugar. These are the three disaccharides.

We started with the disaccharides so you can see the monosaccharides chained together. Sucrose, which is the common sugar that people eat, that's table sugar. I remember growing up with the big sugar bowl. We could go anytime we wanted to and just take a spoonful of sugar. That is sucrose, generally. The sucrose is composed of one fructose and one glucose. If you look at the picture, what you see is the hexagonal shape, the one with six atoms around. That is your glucose. The pentagonal, which is five, that is your fructose. Fructose still have six carbons just like glucose. They are actually the same molecular formula. They are just a different structure. It is very important and very interesting to note how, in biochemistry, just a slight, slight change in either the shape or the composition of a particular molecule can result in a completely different action in the body.

Back to sucrose: the enzyme, which is required to break the bond in between the two molecules, which would be glucose and fructose is actually called sucrase. Most enzymes have the ending "ase" as we have been learning. Lactose is milk sugar. Lactose is composed of two sugars. One is galactose and the other one is glucose. They are very similar in the way they look; it is just that there is a little bit of flipping of one side. It's like one is the other, but slightly flipped on its end.

The enzyme, which I am sure you have heard about in a lot of conditions related to bloating, gas and diarrhea, is lactase. The lactase enzyme is required to break apart the lactose and the glucose. When we have these disaccharides going down into the lower part of the intestine because of the lack of enzymes to break them down, we get a lot of negative byproducts such as fermentation and putrefaction of these sugars by the gut bacteria.

Finally we've got maltose. Maltose is two glucoses chained together. The enzyme that breaks them apart is, not surprisingly, maltase.

Let's look in more detail at those monosaccharides that we just talked about. We've got glucose, fructose, and galactose. There is glucose. It has the six carbons. There is an outer ring of the six atoms. Five of them are carbon and one of them is oxygen.

We have fructose, which is a five-sided structure, a pentagon, and it's got four carbons around it and one oxygen. The other two carbons are in the outer, hanging-off-the-side chains off the central core.

The galactose looks very similar to glucose, but if you look you will see that the upper left hand, hydrogen on the glucose is now an oxygen combined with hydrogen and on the opposite side you will see that it is flipped the other way. Basically in the galactose, the OHs are on the topmost part and the hydrogens are on the bottom most part and on the glucose it is opposite. Very tiny changes. You don't have to memorize this. It would be great if you could recognize these but it is confusing. Know that just a tiny little change in the molecular structure can make a huge change in the way that the molecule functions in the body.

Let's look in more detail at glucose. Glucose is transported across the intestinal brush border: that is the epithelial lining of the intestine, small intestine, in particular the jejunum, the part of the small intestine that does the absorption. There is a transporter that is dependent on sodium called SGLUT-1. In order to have the glucose transported you need to have enough sodium, which means things that deplete sodium can have an effect on the transport. There is a really nice little write-up about that. You are welcome to look at if you want to know more detail about how that transporter works. Once glucose is transported across the intestinal lining and gets into the bloodstream you are not home free yet. You've got to get that glucose into the cells. In order for the glucose to get into the cells it has to be attached to insulin. Once it is in the cells it will get converted into ATP only in the presence of all the nutrients that are required--amino acids, B vitamins, and some minerals, and some antioxidants like CoQ10.

Let's look at fructose. Fructose is another matter. It is quite interesting to study. I am giving you an overview and I am also giving you links to where you can find out more. You will find out on the page where this video is housed or on another page of this website you will actually see some references. It is probably on the *Resources* page. You'll see some references so you can learn a lot more about fructose. First of all fructose does not require insulin but really only tiny amounts of fructose circulates in the blood. Fructose doesn't actually get into the blood in any great amount. The transporter that it requires is called GLUT5 and that is what is required to get it into the cells. It does not need insulin but it needs this other transporter called GLUT5. For the most part the fructose goes to the liver. That is where the majority of fructose goes to and is metabolized. Once it gets there it is considered a good way to store energy so it is converted into triglycerides in the liver. So very little of the fructose that we eat actually gets converted into energy directly.

It usually gets converted into triglycerides in the liver and it is stored as fat and then it can be called upon later to be burned, but it is burned as a fat rather than fructose. The problem is that consumption of high-fructose meals can decrease the insulin and leptin concentration. This is not good because we are trying to help the glucose that usually comes along with the fructose to get into the cells. If high-fructose meals decrease the level of insulin then what will happen is that we will not be able to get the glucose into the cells. And the leptin as well, which tells the body that we are satiated.

High consumption of fructose actually leads to an increase of hunger and sugar cravings. Fructose actually, because it gets converted in the liver to triglycerides, will actually increase the blood levels of triglycerides. Another downside of fructose is that it does not suppress ghrelin. When you combine the fact that it affects the leptin concentrations, it does not suppress ghrelin, which is a hormone that gets secreted by the stomach to signal that we are hungry, then it does not turn off the appetite. You can get this ghrelin signal, you can be hungry, you can then have something that contains fructose or high-fructose corn syrup, and still be hungry. I am sure you hear that a lot. I do, too, from my clients.
Also, the hepatic metabolism of fructose favors lipogenesis. What does that mean? It means that the metabolism of fructose in the liver favors, causes, the production of fat versus the burning of the fructose as fuel. Or the storage of the fructose as glycogen. That is not fun. We do not want to be advising our clients to do things that cause an increase in fat production. The other thing is related to cardiovascular health. Fructose, in significant quantities, is correlated with smaller LDL particle size, which leads to increased cardiovascular risk. What does that mean? You know that we have HDLs and LDLs. LDLs are low-density lipoprotein. This means that there is not very much protein and a lot of fat.

The smaller those particles are, the more concentrated they are in fat and the higher the cardiovascular disease risk. High fructose consumption has been correlated with smaller LDL particle size and thus increases cardiovascular risk. There is a lot of research out there that points to the fact that it is sugar consumption, and in particular high-fructose corn syrup and fructose consumption, that increases cardiovascular risk even more than many fats. Quite interesting. There is so much of a push for fructose, high-fructose corn syrup, and even the things that don't say high-fructose corn syrup, that say fructose, it is still isolated fructose. It acts differently when you take it in as fruit as long as you take it in as the whole fresh fruit, because there is fiber in there and other nutrients that help with this process, but still a lot of people who are fructose sensitive can’t even do too much in the way of fruit sugar.

The fructose from added sugar also increases plasma uric acid. Uric acid can contribute to kidney stones and it can also contribute to gout. When the uric acid crystals get deposited in the joints, then it increases the probability of developing gout and it is certainly painful. It also contributes to *advanced glycation end products*. What are these? They are also called AGEs. These are sugarcoated molecules in the body. The sugar latches on to various proteins in the body and we end up with these dangerous molecules, formations, that can damage, that can cause oxidation, which can cause all sorts of problems. We want to avoid that. It can also change the metabolic hormone response and that can contribute to decreased satiety. We already mentioned that a little bit in terms of leptin and its effect on ghrelin and not turning that off.

What you will find and you can even experiment with yourself if you still do eat fructose, is to see how you feel after eating a certain amount of calories from fructose versus the same amount of calories from something like a handful of nuts or a salad with a nice dressing. It is highly lipogenic when consumed in high quantities and it is moderately lipogenic when consumed in moderate quantities and is slightly lipogenic when it is consumed in low quantities. What does that mean? Lipogenic, it means it contributes to the genesis or the creation of fat, lipo fat. Basically it goes back to helping form more triglycerides and stores fat. So the same number of calories as fructose compared to the same number of calories as coconut, you are going to find that the fructose is more likely to contribute to increased fat than would be the coconut; which is kind of the opposite of what a lot of folks believe. They believe fat causes fat, but actually sugar creates fat for the most part.

The other piece about fructose is it can contribute to insulin resistance in the liver, which means that you are going to get chronically elevated insulin levels, blood sugar levels, because why? If the cells in the liver are even insensitive to insulin, then you are not even going to get the sugar in the blood to be able to be stored in the liver as glycogen. This is going to lead to elevated blood sugars, which increases all of the risks associated with diabetes. It can also cause an increase of cholesterol levels as well as triglycerides as we already talked about. Fructose is not really friendly. People think, ‘oh fructose, it is fruit sugar so it is okay.’

Yes it is okay if it is part of the whole package, the way that nature intended it to be, but if you are pulling it out and away from the package it is problematic. The reason it is okay in the fruits, as long as it is not in excessive amounts, is that fruits have lots of water and fiber and they tend to have a low-energy density compared to the quantity and the filling capacity.

It takes a while to chew them and it is really hard to overeat fructose by eating fruit because the fiber and water fill you up. However, if you juice the fruit it is very easy to get excessive amounts of fructose. We are talking eating whole fresh fruit because it is going to be self-limiting. Some people have to avoid the whole fresh fruit especially the high-glycemics while they are in the throes of trying to restore insulin sensitivity. But on the whole, people should be eating fruit, and a decent amount of fruit, and whatever the body allows.

When people add fruit to the diet, a lot of times it increases their caloric intake elsewhere because you are too full to eat anything else. Try it sometime. Try eating 200 calories worth of fresh fruit, and then try eating/drinking, 200 calories worth of fruit juice *or* dried fruit *or* a snack that is sweetened with fructose, and you will find that you are much fuller when eating the fresh fruit for the most part. So while fructose from added sugars is bad, it does not have the same effect as if it were from real foods like fruits.

This chart is from Wikipedia. It is a chart to help you look at various fruits and vegetables. Their total carbohydrate content and that includes the fiber; their total sugar content, and how much of that is fructose, glucose, or sucrose. It is kind of telling. You can see if there are specific fruits that are higher in fructose than others. Figs, dried figs, 22.9 grams of fructose in100 grams. It is 100 grams of figs compared to 100 grams of bananas has 22.9g versus 4.9g fructose.

What comes close to the dried fruit in fructose content: nothing. Apples probably are the closest. When we look at the total sugar content of figs, it is 47.9g in 100 grams versus, say, what is the lowest here? The lowest in terms of the fruit would be something like an orange (8.5g/100g). They do not have berries up here but you get the idea. In terms of vegetables, some vegetables still have some fructose and they still have some sugar in them but it is much, much lower. Beets and carrots are the highest. Corn which isn't really a vegetable, it is a starch, then sweet red pepper has a substantial amount. Onion, surprisingly onion has more than a sweet potato but the quantity that you would normally eat of an onion is much less than you would of a sweet potato. This is just for your reference, your curiosity and just for fun, and also when people ask you about specific foods you can give them an answer.

Galactose is milk sugar and it comes from the breakdown of lactose. Lactose is the combination of galactose and glucose bonded together. In order to be able to break that bond apart you need to have an enzyme called lactase. I am sure you have heard of lactase. Just about everybody has heard of lactase because lactase is deficient in a lot of people, most people actually, after the age of four or after the age of weaning.

When people don't have enough of the lactase, they cannot break apart the lactose into galactose and glucose, which means those sugars cannot get absorbed into the intestinal lining and into the bloodstream and then they get pushed down further into the intestinal tract causing a lot of gas and bloating as our intestinal bacteria start to break them down. It can be converted to glucose via glucose-6-phosphate. There is a reference that shows those charts and that metabolic process. It is quite complicated. There are some studies that show a correlation to ovarian cancer. There are others that do not, so the jury is out on that one. But since ovarian cancer is pretty serious my recommendation is: until it is proven that there is *not* a correlation to ovarian cancer beyond a shadow of a doubt, I would be really cautious about it. And certainly let your patients know who have a tendency towards those kind of conditions, or hormonally-related cancers, or at high risk for other reasons, to be really careful. I just recommend they get off dairy altogether.

This is an interesting thing that I came across in my research. Galactose is actually a component within the blood typing system, the ABO blood type. Whereas A and O have *two* galactose molecules, there are *three* in the B blood type. Just another interesting tidbit of information. I am not sure what that can be used for clinically but I am sure something might come up and it is just nice to know. There is also another interesting tidbit. There is something called Alpha-1, 3-galactose, also called Alpha-Gal for short. It has been seen as a delayed allergy to mammal meat. People who have high levels of this Alpha-1, 3-galactose, actually have delayed hypersensitivity to mammal meat meaning, pork, beef, lamb and others.

Oligosaccharides are actually monosaccharides chained together, and there are anywhere from three to up to nine of these. Once it goes over nine they start to be considered polysaccharides. One of the oligosaccharides that you may have heard of is called fructo-oligosaccharides (FOS). Fructo-oligosaccharides have had a lot of press and a lot of research because of their ability to provide fuel for our intestinal bacteria; the good guys that we want to grow, without actually providing fuel for us. If you were to take in this chain of fructose molecules, that is usually one glucose combined with any number of fructose is so it could be a glucose at the top and a fructose at the bottom and any number up until around seven of these fructose in the middle. So it is a glucose head with a string of fructoses behind it and they are different numbers.

So the different fructo-oligosaccharides have different numbers. When you take that in, it does not provide calories but we cannot actually break them down. We do not have the enzymatic machinery to break those bonds so it passes through the intestinal tract intact and provides fuel for our intestinal bacteria that do.

Amylose is one of those oligosaccharides and amylose is basically three glucoses or three or more glucoses strung together. Then when you string amyloses together you get a longer chain which is a fiber called amylopectin.

We talk a lot about sugar. Sugar gets a bad rap. Do we need it? There are a lot of people who think, ‘no, we don't need carbohydrates we just need protein and fat in the diet’, but there are studies that show that we do need it, we do need the sugars. First of all there are parts of the brain that only run on glucose. They have a hard time running efficiently on ketones so they have to have a little bit of sugar. In general there are a lot of reasons why you need sugar on a regular basis. I don't mean that you sit and eat table sugar, I mean foods that break down into a little bit of sugar.

Let's go into the details about why you need sugar. The main reason why we need sugar, we need glucose in our bloodstream, is for energy. That is it. That's like we need it. For people to say we don't need it, it is crazy. It is a lack of understanding. We need sugar in the bloodstream. We need to have glucose circulating and it needs to be at a certain level in order for us to feel okay and to have the energy we need to do all of these functions. The range that you will see when you look at somebody’s bloodwork, when you look at someone fasting blood work, generally glucose is in the neighborhood of 75 to 85. It can go a little lower than that and still be just fine, like at 65. Higher than that you start to get into trouble and you start to get into *pre*-insulin resistance. We will talk more about that in our *Blood Sugar* program.

Sugar is important for energy. Why do we need that energy? We need optimal cellular growth and repair. If you are not making enough energy you are going to see dry, flaky skin. You are going to see wounds that don’t heal, you are going to see very slow response to hair growth and nail growth. You are just going to see some changes if you don't have the energy at a cellular level. You also need the energy for organ and gland function. When you see people that have sluggish adrenal function or sluggish thyroid function or sluggish digestion, it could be a matter of not getting the right amount of sugar and ATP processed in the system. Of course we need sugar for mental clarity and attention. We need energy to provide mental clarity, to be able to think things through, to be able to access the wizard brain and get out of the lizard brain, and to be able to focus. Energy is super important for steady moods. People who have sugar ups and downs will tend to be irritable and grouchy and there are also the things that are just not fun when we are in the state of low sugar or fluctuating sugar, up down, up down, irritable, cranky, depressed, anxious. You need energy to have fun and you really need to be emphasizing that with your clients.

Having fun is a really important part of their health picture. Good clean fun, not fun that it's going to get them in a state of biochemical disarray like going out for pizza and beer or smoking cigarettes or doing recreational drugs. That may appear to be fun at the time but in the long run it is damaging. We are talking about good fun like going out for walks, going out and checking out wildlife and flowers, doing puzzles, doing artwork, going to amusement parks, travel, going to the beach, fun, really good fun that is going to contribute to health. We need energy for meaningful relationships. I don't know if you have ever been in a situation where you are in a relationship and you are exhausted or they are exhausted. It is not fun when you cannot connect with each other and have good times. Finally achieving success in your chosen career. You are here because your chosen career is to help people overcome health challenges and get well. In order for you to do that well, you need to have the right amount of sugar in your system and the right processing of that sugar into ATP.

Let's look at the best sources and the least desirable sources of sugar in our diet. On the less desirable side we had the most common which is table sugar or sucrose. I remember growing up with that sugar bowl on the table. We have fructose in the form of high-fructose corn syrup and also just fractionated, isolated fructose that is added to things. We have glucose syrup. You don't see that a lot. You see more in Europe.

It is actually metabolized more easily by the body than the combination of sucrose and fructose that we have here. Glucose is able to be taken right in. It requires very little processing. High-fructose corn syrup which has become the bane of our society and it is just over the last few decades that the manufacturers have really brainwashed people into thinking, ‘well, it is from corn, it has fructose which comes in fruit therefore it must be a good, healthy sweetener.’ People are becoming aware that it is not.

Maple syrup. People think ‘wow, it is maple syrup, it comes straight from the tree and it still has some B vitamins in it’, but it is a source of simple sugar and is especially problematic for those don't have really good blood sugar regulation capacities. These are a couple of other refined sugars that are relatively new on the market in the last 10 years: agave, coconut nectar, and palm sugar. They have been raved about as sugars that don't raise the blood sugar level that much and that keeps things nice and steady, but in reality they are simple sugars. They may be slightly better than fructose or sucrose but they are still problematic. I have done lots of blood sugar testing with people and there are quite a number of people whose blood sugars go up when they consume these kinds of sugars.

Honey is another one. It has been around forever and it has been considered a health food forever but again it is a simple sugar and it gets in there right away. It is very easy to get absorbed and very quick to be absorbed. Even if it has some nutrients, it may not be enough to really metabolize it well in some people.

Finally refined grains. People think ‘what do you mean, grains are sugar?’ How can grains be sugar? They are grains. They are starches. Well, they get converted so quickly into sugar that if you are eating a piece of white bread or some white pasta or anything like that, it's just going to cause a really big sugar spike in the body.

Let's look at the best sources of sugar. Believe it or not green leafy vegetables, they actually have some sugar and carbs. That chart that I showed you earlier, you will see that. Not a lot but that is the beauty of them. They provide small amounts of glucose and sucrose and fructose with very low concentration of calories because of how much fiber and water and minerals are in them. That is your absolute best source of carbohydrates or sugars. Rainbow-colored vegetables: a little bit higher in the sugar content for example beets, carrots, and red bell peppers. If you look at the chart you will see slightly higher levels of sugars in there but again, they are complex with very, very good fiber structure and lots of water, which helps them to get used much more slowly.

The next source of sugar which is more of a complex, which means it takes longer to break down and digest and get into the sugar, which means it gives you a nice steady, slow uptake of sugar into the system for most people, there are some people that it is much quicker for, are the root vegetables and tubers. Those would be things like your winter squash, beets and carrots again, sweet potatoes and yams, and potatoes. White potatoes tend to be a higher, even if they are complex, they still tend in studies to show that they raise the blood sugar much more quickly than other tubers. Then we've got fruit, bananas, apples, pears, blueberries, and they are all different in how much sugar they contain and how quickly they will raise your blood sugar. It is very independent. When we look at the blood sugar balancing part of the course you will see that there are ways for you to actually measure and figure out for each person which fruits work really well and which fruits are actually being absorbed too quickly.

Whole non-gluten grains. I am talking *whole* here. I am not talking flour products. I am not talking pasta, bread, crackers made with whole grains, no, I am talking the whole grains so millet, quinoa, brown rice, buckwheat, teff, and amaranth, those are whole, non-gluten grains.

When you slow simmer them and keep them intact and don't break them apart, the sugars are absorbed much more slowly. Same thing with legumes, they have small amounts of sugars. In fact some of those carbohydrates in legumes give the notorious 'tooting' syndrome, the gas that comes with legumes because there are particular sugars in there that our bodies have a difficult time breaking down. Nuts and seeds do have a little bit. Not a whole lot and some more than others but they will have a little bit of sugars in them. Those are the healthy ones.

Let's now talk about getting the sugar into the cells. We have talked briefly about insulin and you will hear about insulin over and over again when we get to our *Blood Sugar Balancing* module. But it requires enough insulin so you need to have a pancreas that can produce enough insulin. Some of the things that can thwart the pancreas from producing enough insulin are inflammatory conditions and autoimmune. It is actually possible to be making antibodies to the pancreas, the islet cells in the pancreas that make the insulin. It is also possible for making enough insulin but having that be attacked because a lot of people have anti-insulin antibodies. You are going to see more of these in the cases of type I diabetes or people that are heading towards type I diabetes.

The second thing we need to get sugar into the cells and working for you is guess what? Healthy insulin receptors. You can produce all the insulin in the world but if the receptors have closed their ears to the signal, to the sounds of insulin tapping on their doors, then it is not going to get in and the sugars are not going to get in. Finally we need nutrients. There are nutrients that are required to support the transport of the insulin attached to the sugar and get it into the cells. Some of those nutrients are things like your B vitamins and things like chromium, magnesium, and even the nonessential fats but the omega-3 fat DHA.

It is essential for body functions but not essential necessarily to have any diet because the body can make it. So remember we made a distinction between essential and nonessential when it comes to the macronutrients. We need, in order to get the sugar into the cells so they can be processed by the ATP, we need insulin, healthy insulin receptors, a healthy immune system so it is not attacking, we need the nutrients, and the main nutrients that I find to be deficient in people when they have difficulties in getting sugar into their cells is chromium. Chromium polynicotinate is the form that has been used most commonly.

Let's take a look at how sugars are converted into energy. This is just a little bit of review because we went over this in great detail in our *Cellular Metabolism* module. This is basically the Krebs cycle.

You know that sugars go into the cycle and it goes around and just gets converted and there is a transfer of carbons and carbon dioxide is released and it is just constant ‘through the cycle’ until what comes out is ATP. That is the Krebs cycle and I highly recommend you go back and study that if you are feeling unfamiliar with it at this point.

What are the negative effects of simple sugars? We hear it all the time. You probably have said it to your clients a number of times, get rid of the sugars, get rid of the sugars, there are a lot of deleterious effects. It is really important for you to be able to articulate those to your clients so that they are feeling empowered to do it, not just another rule. They understand what impact it is having on them. When you can relate the negative effects of the sugar to them, to their life, to their goals, to what you know is important to them, it's going to be much more likely to be effective in helping them to get off it and stay off it.

What I find with sugar, is that folks get/are addicted to it, and they are addicted to it on a physiological basic and they are also addicted to it on an emotional basis. It is comfort. Some of the things that have to happen when you are having the conversation about sugar with someone is to really, you get to ask the right questions to understand, what is their connection with the sugar? Is it that they need it to keep their energy up? Is it that they have poor blood sugar metabolism, they are up-and-down and are getting cravings? Is it a hormonal imbalance? Is it a psychological connection to sugar as comfort? It is very commonly used as a comfort food. Let's have a look at some of these things.

First of all, one of the negative effects is blood sugar imbalance leading to insulin resistance and potentially diabetes. What happens when people are taking in simple sugars, we know that it triggers the release of insulin from the pancreas, raises the insulin levels, the insulin does its job of putting the sugar into the cells, but over time the cells become resistant for any number of reasons. One of the reasons is insulin can be damaging to the cells. Insulin can cause a loss of elasticity to the cells. Insulin can cause a thickening of the cell membrane and a loss of the great transmittal function.

Basically it can cause problems. It can cause issues that the body is trying to protect itself from so it naturally becomes insulin resistant. Plus the sugar, there is just so much sugar we need to have going into those cells at any point in time. When we are bombarded with it is just too much and it overpowers the mechanisms and the ability of the body to convert it into energy. The cells say ‘enough’. Then the sugar sits there. When the cells say enough and it truly is enough that is fine.

But after a while the cells start to say enough because we have used up all the nutrients that are needed for the transport like chromium and the magnesium and DHA and the CoQ10 and a lot of others. The body just gets, ‘it’s done’. When you get this insulin resistance over time, the sugars stay high and then the body has to deal with the negative effects of elevated sugars, which is the glycosylation of hemoglobin and the kind of thickening and stickiness of the blood cells. Eventually it can cause damage to peripheral arteries, peripheral nerves, etc. We really want to help people maintain blood sugar. That is done, once they have developed insulin resistance, by taking away all of the sugar for a period of say 3 to 4 weeks, and then allowing those receptors to reset.

Another obvious one, mom told you that when you were a kid, don't eat too much sugar, you are going to get dental cavities. Indeed the sugar feeds the bacteria in the mouth, the very acidic forming bacteria in the mouth, which causes plaque on the teeth which decays the teeth. That is an obvious one. Everybody knows that one.

Decreased immunity is one that a lot of folks don't get. What happens when you take in a dose of sugar, it causes a decrease in the white blood cells called macrophages, which are basically the Pac-Man of the body. They go around and gobble up bacteria, viruses, and things that are no good for us. When you have an influx of simple sugar, the macrophages go down significantly. There are a lot of studies that talk about this. Specifically I have seen anywhere from the range of, they go down by 50% for a period of two hours with a dose that is equivalent to a teaspoon or two of sugar, all the way up to, say, a 90% decrease in their effectiveness for 6 to 8 hours after something like a Coca-Cola, which is about 6-8 teaspoons of sugar; a lot sugar.

The other thing is that it accelerates cancer cells. Cancer cells have extra insulin receptors on their membranes and they do not get resistant. Cancer cells thrive on keeping themselves alive and they want to gobble up all the nutrients out of the body, so they will gobble up the sugars because they've got the little flags on the insulin receptors saying ‘feed me, feed me’. Likely the regular cells have resistance and they are not accepting the sugar. Sugar will accelerate the growth of cancer. Many anticancer programs in the natural health community, nutritional community, all sugars, including fruits, are taken away during the treatment of cancer. Not to say that fruit causes cancer. By no stretch can we say that, but once cancer has developed in a unhealthy body, the presence of fruit can accelerate its growth.

Sugar can cause premature aging. That is from a lot of that by glycosylation that happens from the excess sugar in the system.

We find that people skin loses elasticity, the collagen gets less plump and we age prematurely. Another thing, and a lot of these are documented in a really nice book called *Sugar Shock*, and these are a lot of documented studies from the medical literature. We talked about the hostility and aggressiveness that happens when people are on sugars. It affects the brain chemistry. What happens is, there is a brain chemical called serotonin. It is a neurotransmitter. Sugar actually increases levels of serotonin temporarily, very temporarily, because once the effect of the sugar wears off, those levels drop down and you get cranky and irritable because of the up down, up down of the serotonin levels. It is very important to stay away from it.

There also have been some studies that show that there is decreased libido with the intake of sugar, that people lose interest… Some explanations were as simple as, well, they are getting more satisfaction from the sugar than they are from sex or from their partner, all the way to creating hormonal imbalances and immune system imbalances and all of that. It has also been linked with Alzheimer's. Recently, over the last few years, *Alzheimer's* has started to be referred to as *insulin resistance of the brain* or *type III diabetes*. In fact there are insulin receptors that become resistant to some of the cells in the brain that are responsible for short-term memory. One of those things that it can lead to is actually Alzheimer's. Alzheimer's is not fun. When you are talking to your clients and explaining to them the downside of sugar, ask them if they have had any relatives who have started to lose their mind or who has Alzheimer's or another kind of dementia. It's not fun. I don't think it is anything that anybody would want to look forward to. If there are things that they could do now to prevent that decline later, all the more reason to do it.

Let's look at a few other things. It certainly depletes B vitamins and other nutrients required for energy production. Think about this. When you eat foods in a whole form, you are getting the full package. You are getting sugars, you are getting proteins, you are getting fat, you are getting B vitamins and minerals. Those things are required for the Krebs cycle to take the sugar and make it usable. If you are eating sugar without the complete package it is going to have to find those nutrients in the body. At first it may be able to at the risk of a functioning being lost, but after a while what is going to happen is the B vitamins are depleted, the minerals are depleted and you are unable to make energy from the sugar that comes in. That may be part of the mechanism of the cell shutting down is don't let any more sugar in because we cannot process it.

The other thing it can cause intestinal distress. You have heard of candida albicans overgrowth and fungal overgrowth in the gut.

A number of bacteria that are not our friends grow in the gut and it can cause problems. Some of these sugars actually start to ferment in the gut and part of it is we lose the ability to break down the disaccharides into monosaccharides for absorption. Though we lose the lactase, sucrase, and maltase and what happens is it causes bloating and gas as the bacteria and the organisms in the gut have a field day. Candida overgrowth is part of that, the intestinal distress candida: they love sugar. When you feed it sugar they thrive and grow out of control and overpower the good bacteria that your body needs to produce B vitamins, to digest food, to keep that nice, friendly, balance into your gut.

Mood swings and depression are very common with sugar. There are the ups and downs. There are a lot of times that it is the downside, it is when someone is on the sugar, when he eats the sugar, they are feeling phenomenal but it does not last and it is the dip that causes them to go back and crave the sugar again. Mood swings and depression are very commonly associated with the intake of simple sugars. Of course there is addiction. You hear people all of the time say they have to have their fix. I was visiting someone once. She was out and was going to be home late. She said another friend was coming over for the evening and her friend might get there before her. I said okay.

I was in the kitchen and I was sitting there doing some computer work or whatever, and she came in and said, ‘do you have anything sweet to eat?’ I said ‘no, not really, I don't eat sweets’. She said ‘I wonder if there are any sweets here, do you know where she might keep her sweets?’ I said t’here is a drawer over there’… She said ‘I just need some sweets’. She looked around and didn't see anything. Then she saw some nuts. I said ‘I have some…’ I had something that might have been Stevia sweetened. She said ‘no, I need sugar’. She was desperate for something sweet. I was just watching this in amazement. It becomes obsessive.

I'm sure you have either felt that way at times or have seen people that way at times. The other thing that sugar does is it contributes to inflammation. They contribute to imbalances in the pathways where fatty acids are processed to create anti-inflammatory prostaglandins. If you are unfamiliar with that process make sure you go back and review the inflammatory pathways in the fat module but you will see that sugar is very key in there and it depletes the B vitamins, it depletes the minerals, and all that is needed to control inflammation. There is so much more. If you want to go into more depth in Chapter 4 of the textbook, the nutrition and biochemistry, has some good information in it. I recommend *Sugar Shock* by Connie Bennett. There is some very interesting stuff but it is backed up so you can actually go from there to look at the science if you are the kind that likes to do that.

How do we assess a person's tolerance to various sugars? We have a whole big module on this in the *Blood Sugar Balancing* program part of this, but we have ways to home test. I will give you an overview and you will learn way more when you go in there with charts and what it should be, and all of that. Home testing is phenomenal. A lot of people, when they suspect they have hypoglycemia and they go to the doctor and the doctor says let's do a glucose tolerance test. They have to go to the office and drink this yucky syrup and they measure how high the sugar goes. It is an artificial, contrived situation. I certainly understand the value of seeing how your body responds under the worst circumstance of taking 50 or 100 grams of pure sugar and what does your body do?

In an ideal world where the body is well balanced it does not do much of anything. The sugar may start at 85, and go up to 108 and go back down to 85 in two hours. That is what a good, healthy person would be. The majority people who do these glucose tolerance tests are not healthy people. When you give them a test like that it just causes so much distress because they may already have given up those kinds of foods, and they are just trying to struggle to find out what is going on with them. I do not like doing that with people. What I like doing is teaching people how to do a glucose tolerance test at their own home using the foods they normally eat. Have them pick the worst meal that they ever eat: the highest carbohydrate meal.

If they are just someone that is new and are coming off the standard American diet that might just be croissants, sweet tea, and other things like that, but for other folks it is not. They have already given up that stuff but they are still doing things like fruit juice or they are still eating blueberry yogurt. There are other things like that. So I have them tell me what their highest carbohydrate meal is and we will talk about what those might be. I will tell them to have that meal the first thing in the morning and then give them a chart to track their glucose over the next few hours. They can do it quite inexpensively at home. Where as in the office it may cost somewhere in the neighborhood of several hundred dollars, at home it is just a matter of spending $10 or $15 for the glucose meter and then you would probably go through maybe a half a box of strips over the course of the day which would be another $10 so for somewhere in between the $20 and $25 range to do it in the comfort of your own home, you are tracking your own sugar, you are charting it, and finding out how that worst meal affects you.

Once you figure out how that worst meal affects you, I have them do it for a variety of foods. I will have them check for food that we want them to start eating, food that they already eat that might be questionable.

Some of the foods that they don't suspect will cause a problem so we can get a repertoire of foods and teach them how to eat for blood sugar balance which we will go through in great detail in the *Blood Sugar Balancing* part of the program.

In addition to home testing for glucose tolerance, and you can do it in many different ways, which we go into great detail later, but lab testing can be done. There are a number of different lab tests that are really important for assessing blood glucose. Fasting blood glucose is actually one of the least valuable because it just gives what that person's fasting is first thing in the morning when they get up. It is not tell us at all how they respond to food. In fact when we are heading on the continuum towards diabetes, the fasting blood glucose gets altered and is out of the normal range long after there has been a standing problem with glucose and a lot of damage that has been done.

It has been said that every time blood glucose goes above 120, there is damage to the peripheral nerves, which lead to peripheral neuropathy, which is very common in diabetes. The way that the standard medical approach is to look at diabetes is once the fasting blood sugar gets above 120, that person has diabetes but if the fasting blood sugar gets above 120 it means that the non-fasting have been way above 120 for a long time which means that the poor person, instead of being caught early and given the strategies to reverse it, they are going to be stuck with this damage to the peripheral nerves, including retina, to the kidneys, and other parts of the body. So fasting blood glucose is not very valuable especially if the person has their own meter, then they can do it at home.

But hemoglobin A1C measures the effect of glucose over the course of three or four months. It actually looks at the red blood cells and sees how much of the hemoglobin is actually sugarcoated. That is what glycosylated hemoglobin is. That is what hemoglobin A1C is. When there is a lot of sugar that has been in the bloodstream, the red blood cells naturally, some percentage of them, are going to become sugarcoated. The normal, the average, the good amount should be somewhere between 4.5 and 5%. When it goes above 5% it indicates that there is an issue. It is considered in the insulin resistance diabetic range when it goes above 5.7.

Frankly, it is kind of crazy but for diabetics it is considered under control if it gets down to seven because diabetics, when they are diagnosed, they are generally ranging in the hemoglobin A1C in the 10 or 11 range, so they are trying to get them down to seven.

When you do the calculations, and we teach you how to do that in the other program, the blood sugar balancing part of the program, you will see that the average blood glucose, when the hemoglobin A1C is up in the 11s, is somewhere in the 180 or 200 range. When it is at 5.7, the average blood glucose is somewhere in the 130 range. You can see that we want the average blood glucose to be a lot lower than that. I like to be at least less than 100 because that takes into account not only the after dinner and after meals glucose but throughout the night when the person is fasting and it should be low.

If you average that out and say that overnight they are in the 80s and their average, based on hemoglobin A1C, is in the 120s, that means a lot of the time they are way up higher than that. That is scary. We use that to measure long-term and will go into that later. I want you to be familiar with these things so you can start looking at your clients especially if they bring in lab testing that they have done through their practitioner.

Fructosamine is similar to hemoglobin A1C. Fructosamine is measuring amino acids that are coated with fructose, so it is basically similar but it shifts more quickly. With the hemoglobin A1C, red blood cells last for about a 120 days. So the hemoglobin A1C is going to give you the averages over 120 days. So if you make changes or get your client to make changes, you cannot really go back and test it in a month to see how well it is doing. You have to wait. Of course you can look at the glucose and be monitoring that throughout the day, but you cannot see the effect on the hemoglobin A1C until three to four months. Whereas with fructosamine you can check it once a month and see. Is it as accurate? The jury is out. There is some controversy over whether it is, but I think it is actually a decent measure.

The last one on the lab testing that is going to give you some information about how people are handling sugars is, of course, their insulin level. I like to look at their fasting insulin level and I also like to look at their post-prandial insulin level, which means their insulin after meals. Fasting is a good way to get it because if the person is becoming insulin resistant, you are going to see high levels of fasting blood sugar. If they are severely insulin resistant, or actually becoming and crossing over to insulin resistance. When you see a high, elevated, fasting insulin you know that the person is in an insulin resistance phase. What is a good level? I like to see between three and five. That is what a good level would be. When it gets very low you start to suspect that their pancreas is no longer making enough insulin and you've got to do some more deep testing. It might be a type I diabetes or a late onset adult diabetes. We will talk more about that in *Blood Sugar Balancing*.

Those are basically the types of testing that you can do to see if your client is handling sugars and to get some momentum behind your recommendation to them to go off it if they need it. Some people are inspired to change and they change and it is not a problem. Other people need a little bit of something, of motivation, so you can show them labs or a specific test and when they do it, it will be more compelling for them.

Now that we talked about the structure of sugar, the role of sugar, the dangers of simple sugars, how to test for the sugar balance, we are going to look at how you can coach your clients and what are the best alternatives to sugar for satisfying the sweet tooth. My top favorite is actually Stevia. Why? Because it is a green plant. You can grow some in the yard and it looks a little similar to mint. It is quite lovely. You can actually go out and eat the leaves and fresh is best. You can also get dehydrated Stevia which is basically the leaves that have been dehydrated. That is the next one. After that, my next favorite would be *Sweet Leaf* concentrated Stevia and the reason for that is what they do is they take the whole fresh leaves and they basically boil them down into a concentrated syrup like consistency. It still has everything in it and it is starting to the fresh plant. The white Stevias, all of the coloring has been removed, the chlorophyll has been removed, and it is just simply white. Oftentimes it has been adulterated with other things like dextrose and rice flour. So be careful with those. These are the kinds of Stevia. I think fresh Is best. So go get a plant. You can probably growth in the kitchen. I know you can grow it in your yard. We used to do that.

Next would be the green powder. Brands, some of the nice brands that sell herbs like *Frontier Herbs* and *Mountain Rose Herbs*, they all have a variety of their green Stevia. Try them out and see what tastes best. With a *Sweet Leaf* they actually have a bunch of different flavored *Sweet Leaf* concentrates. I have coconut and cinnamon and chocolate and hazelnut and vanilla.

Another alternative to sugar would be a Chinese herb called Lo Han. You've got to be careful with low on because there are a lot of companies that will make it but they will adulterate it with things like fructose and dextrose; so you want to get some pure Lo Han. There are places where you can find it. I know Swanson has it and there are a number of places that have the pure Lo Han. It comes as a white powder. You can mix it. It mixes very well with Stevia. It tends to take a little bit of the edge off of the bitterness that some people perceive with Stevia. Another one is erythritol, which is in the family of sugar alcohols. Sugar alcohols are not alcohol and are not sugar. We will look at more detail of the different kinds of sugar alcohols and I have a chart for you to compare them.

My favorite is erythritol mainly because it does not get digested, it does not pass into the lower bowel, the large intestine, like the other sugar alcohols where they are subject to possible fermentation by bad gut bacteria and causing bloating and gas. With erythritol, we are basically looking at being absorbed further up in the small intestines, so it doesn't really pass through the rest of the intestinal tract. It has a 0 calorie count and a zero glycemic index whereas the others have a little bit more because it is passing through and some of the sugars are actually getting absorbed.

Chicory root inulin. This is a new one. I have been trying to work on testing it. I have tested it a little bit and so far it looks good. It comes as either a powder. There is a brand called *Just Like Sugar*. Or it comes in syrup. It works pretty well. It is similar to Jerusalem artichoke syrup, which is also high in inulin. Inulin, as you recall, is a long starch/fiber form of the fructo-oligosaccharides. It is a string of fructo-oligosaccharides strung together. When it breaks down it can actually create good food for the gut and it is not metabolized and it is not caloric for us. Yacon is another one. It is a tuber that grows in South America. It has been used for a while. For some people it raises their blood sugar and for others it does not. I think if you are going to use yucca you are best off with the whole slices or the powder as opposed to the extracts, which tend to be heated and made into a syrup. Those, I think are going to be higher glycemic. It is really a matter of testing

I have never seen anyone have blood sugar elevations from Stevia, LoHan, and erythritol but it is certainly possible with things like chicory, yacon, and the Jerusalem artichoke. I do not have blood sugar elevations from Jerusalem artichoke. I have not noticed it from the chicory root. I have tested it a few times. Yacon I have not really tested.

Let's look at particular products that you can recommend your clients to. What we have pictured here is one called *Lakanto*. That is a combination of erythritol and LoHan. We have *Zero*, which is organic erythritol, and we have *Just like Sugar,* which is the chicory root.

Let's look more closely at sugar alcohols, what they are, what they do, and how they are metabolized in the body. They are also known as polyols. When we look at the FODMAPs diet, FODMAPs are the Fermentable, Oligosaccharides, Disaccharides, Monosaccharides, And Polyols. That's what that stands for. The idea is some people do not digest any of the saccharides. They do not digest any of the sugars including the sugar alcohols and including some starches that break down into the oligosaccharides, etc. You have people come off those saccharides and see how they do. We will go more into that when we do our Digestive module. So polyols don't contain alcohol in spite of them called sugar alcohol.

It is the OH groups on there that are chemically considered alcohol, that's why it is considered sugar alcohol. If you look at the picture you will see the difference between glucose and erythritol and how the glucose to be converted into erythritol. There is actually a process that they can do in the lab that can convert glucose into erythritol.

You can find erythritol in corn and birch. Same thing with xylitol but they can also do a fermentation process with glucose and turn it into erythritol. The sweetness is very similar to sucrose. They have fewer calories, in fact erythritol will have no calories. They are naturally occurring from birch and corn, if you are going to get naturally occurring, I prefer birch because corn is generally GM0. Erythritol from *Zero* is definitely non-GMO and it is organic. The theory is (and I mostly have found this to be true) that they don't raise blood sugar. It is possible that sorbitol or xylitol can actually raise it a little bit because they do have a few calories and they do have a little bit of "sugar" in there, so the breakdown is not complete. But erythritol actually has none so that is why that is my chosen one, and most people do not get digestive upset from erythritol.

Here is a little chart comparing them. Erythritol is a 4-carbon. The others, mannitol and sorbitol are 6-carbon and xylitol is 5-carbon. Compare it with sucrose. The second column is how sweet are they compared to sucrose. Erythritol is 80% sweet as sucrose, mannitol is only 50% and sorbitol 60%. But xylitol is actually equivalent in sweetness. In terms of calories per gram, sucrose would have 4 calories per gram, erythritol has 0.2, so it is just a tiny fraction of calories. Whereas mannitol is 1.6, sorbitol is 2.6, and xylitol is 2.4. Sorbitol and xylitol are actually pretty close. It is not that much less sweet and not that much less caloric.

It is kind of deceiving to think of them as sugar substitutes that are non-caloric. Then when you look at sweetness per food energy, so sweetness per calories relative to sucrose. We have 15 times as much sweetness per calorie in erythritol whereas only 1.6 as much in xylitol. I point to the erythritol and xylitol because those are the ones that you are going to see most. There are a lot of studies on xylitol based on it is ability to help control dental cavities and just basically stop the bacteria in your month from eating away at the teeth. I have not seen those kinds of studies on erythritol.

I have not looked very hard but it is possible they are there. Xylitol is the one that has the most studies and there are a lot of dentists who are recommending that their patients chew xylitol gum after they eat to get their mouth cleaned out. If you want to gargle with it xylitol rinse and a xylitol mouthwash and spit it out, that would be ideal for cleaning the teeth.

As far as chewing gum, I am not a big fan of gum chewing just because it stimulates digestive juices but on the other hand if you are doing it right after a meal it might not be a bad idea to stimulate digestive juices. So those are your sugar alcohols.

Let's just look at a little bit more detail about erythritol and why I think is the best of the sugar alcohols. These are the products that you can get it in. *Zero* is 100%. There is another one called *Smart Sweet* and that the *Smart Sweet* 4.5 pounds you can see the descriptions of it. Most of it is absorbed in the small intestine and is excreted unchanged in the urine and feces. Whatever goes through the intestine gets excreted unchanged; and whatever goes to the urine gets excreted unchanged. Basically you borrow the sweetness and it passes right through.

About ten percent enters the colon but normally it does not cause the laxative effect. Of course it could in someone who is super-sensitive. You have just got to be aware of that. It is generally free of side effects in regular use. Of course in very high quantities anything, even too much water, can be problematic. So doses over 50 grams, who is going to have over 50 grams of this stuff in one sitting? 1.8 ounces can cause nausea and stomach rumbling. It is more difficult for the intestinal bacteria to digest than other bacteria so it is less likely to cause gas or bloating; maybe because it's a 4-carbon, I don't know, but generally that is with the studies have shown. It is naturally occurring in things like pears and melons and grapes, mushrooms, wine, soy sauce, and cheese. That is kind of interesting. That might be what gives part of the sweetness to those things.

Finally, we have gone over a lot here and there is a lot more to know. This might be a topic that you just really want to dig deeper into so in the *Advanced Nutrition and Human Metabolism* textbook that I recommended for the course, in chapter 4, there is a really good explanation of the biochemistry of sugar. *Sugar Shock* by Connie Bennett I thought was really good. There is also *Sugar Blues*. There are a number of others and I have listed those in your reference guide. Some of the statistics that I pulled out about depression and the mood swings etc. were from *Sugar Shock*. Thank you very much.

This is Dr. Ritamarie and we will see you on the next video.