

How to Optimize Your Brain-Body Function & Health | Huberman Lab Podcast #30

This episode I describe how the organs of the body influence the function and health of our brain and how our brain controls our bodily organs. The conscious awareness of this brain-body dialogue is called interoception. I describe how two factors- mechanical forces (e.g., pressure, pain, volume, etc.) and chemical factors (e.g., gut acidity, microbiome diversity, etc.) combine to influence our moods, control inflammation, immune system, recovery from injury and more. I explain how specific actions of our lungs, heart, spleen, and diaphragm, control our brain via the vagus nerve and other neural pathways. I describe 11 science-supported protocols for enhancing brain-body health and the logic behind them.

#HubermanLab #Brain #Health

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- 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, we continue in our discussion about sensation or how we sense things. On previous episodes, we talked about sensing light and sound waves for things like vision and hearing. Today, we are going to talk about our sense of self or what's called interoception. Interoception is our sensing of our internal landscape, things like our heartbeat, our breathing, and our gut, how full our gut might happen to be, or how empty our gut might happen to be. But also our inner landscape with respect to chemistry, how acidic, or how good or bad we feel on the inside. This discussion about sense of self and interoception has many important, actionable items that relate to bodily health and brain health, and believe it or not, our ability to perform well or perform poorly in life. Indeed, it has profound influence on our rates of healing. So today we are going to talk about all the aspects of our inner landscape and how our brain and body communicate. And there will be many actionable protocols

00:01:25 Protocol 1: Fermented Foods, Not Fiber, to Reduce Inflammation

as we go along that discussion. Before we begin our discussion about sense of self, I want to highlight some very recently published research findings that I believe are immediately actionable and that everybody should be aware of. These are data that were published by my colleague, Justin Sonnenberg's laboratory at Stanford University School of Medicine, and the data were published in the Journal Cell, which is a very high stringency cell press journal. So phenomenal data. What this study showed was that

individuals given a high fiber diet actually experienced less diversity of what's called the gut microbiome. The number of positive or health promoting bacteria in the gut was actually reduced by a high fiber diet, whereas individuals that ate just a couple of servings of fermented food each day, experience important and beneficial increases in anti-inflammatory markers. And that could be traced back to improvements in the gut microbiome diversity, the diversity of bugs, literally little bacteria that live in the gut, which might sound bad, but they are actually very health promoting. I'm going to get into all the details of this study later in the episode, but I just wanted to emphasize these findings because they are immediately actionable. I think for most people ingesting one or two servings of fermented food each day is reasonable and does not bring with it tremendous costs or tremendous inconvenience. And I think many people are ingesting high fiber diets thinking that that's the best way to improve their gut microbiome. So while these data may prove to be controversial among the folks out there in the nutrition community, that really high fiber diet, I want to just emphasize that these data were looked at in a very unbiased way. They were done with large scale screens of all sorts of inflammatory markers. There was no specific hypothesis going in. It was purely exploratory, but the data are very clear. It doesn't mean you shouldn't eat fiber doesn't mean that fiber is bad, but it really shows that eating fermented foods, just one or two servings a day, and maybe even ramping up to three or four servings per day

00:03:30 Attributions

can be very beneficial for many aspects of health. Before we go any further. 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. In keeping with that theme, I'd like to thank the sponsors of today's podcast. Our first sponsor is Roka. Roka makes sunglasses and eyeglasses that are of the absolutely highest quality. The company was founded by two All-American swimmers from Stanford and everything about their sunglasses and eyeglasses is developed with performance in mind. I've spent my career working on the visual system and its various functionings within the brain and within the eye, Roka sunglasses and eyeglasses are so phenomenal because they allow the visual system to do what it does best, which is to adjust to changes in what we call luminance or brightness, with many sunglasses out there and with many

eyeglasses as well, if the brightness in the room changes or you get cloud cover, or you walk into a shadow, you have to take the glasses on or off, you can't see as well. But the folks at Roka really understand how the visual system works. And so they've designed their sunglasses and eyeglasses such that you never experienced that shift. You can walk into a shadow. The amount of sunlight can change. You can go into a dark room, et cetera, provided there's enough light to see you're going to see everything crystal clear. In addition you see everything crystal clear because the lens quality is terrific and the sunglasses and eyeglasses are very lightweight. So you don't even notice that they're on your face. Also the sunglasses and eyeglasses are designed for performance. You can use them while running or while cycling. Even if you sweat, they won't slip off your face. And as I mentioned before, they're very lightweight. So everything about these glasses is terrific and they have a terrific aesthetic. They have a lot of different styles to select from. And unlike a lot of performance eyeglasses out there, they won't make you look like a cyborg. You could wear them to dinner or to somebody's home. And they look really nice. If you'd like to try Roka glasses, you can go to Roka that's [ROKA.com](https://www.roka.com) and enter the code Huberman to save 20% off your first order, that's Roka, [ROKA.com](https://www.roka.com) and enter the code Huberman at checkout. Today's podcast is also brought to us by Inside Tracker. Inside Tracker is a personalized nutrition platform that analyzes data from your blood and DNA to help you better meet your health goals. I'm a big believer in getting regular blood work done for the simple reason that many of the factors that impact your immediate and long-term health can only be assessed, can only be measured from a quality blood test. And now with the advent of quality DNA tests, you can get further insight into the status of your immediate and long term health. One of the problems with a lot of blood and DNA tests that are out there, however, is you get the numbers back, you get the levels of metabolic factors, hormones, et cetera, but you don't get any information about what to do with those numbers or how to actually shift them in the direction that you want to. With Inside Tracker, they have this very easy to use dashboard and that dashboard makes it very clear, not just what your levels of hormones, et cetera are, but what actions to take in terms of nutrition or exercise or other lifestyle factors to bring those numbers into the appropriate ranges for you. If you'd like to try inside tracker, you can go to insidetracker.com/huberman. And if you do that, you'll get 25% off any of Inside Trackers plans. Just use the code Huberman at checkout. That's insidetracker.com/huberman to get 25% off any of Inside Trackers plans. Today's podcast is also brought to us by Headspace. Headspace is a meditation

app that's backed by 25 peer reviewed published studies and has over 600,000 five-star reviews. I started meditating when I was in my teens, but for many years I found it hard to maintain a meditation practice, I don't think I'm alone with that. I think many people start meditating. They'll do it for a few weeks or a few months, or maybe even a year. And then they'll give up the meditation practice. And we know from so many peer reviewed studies that meditation has a number of very positive effects on our brain health, our ability to focus and our bodily health. So it's a great thing, we probably should all be doing it, but most of us, including myself, have found it hard to stick to a meditation practice. Then I started using the Headspace app and what I found is I could be very consistent with my meditation practice because they have meditations that are short, meditation that are medium length, and meditations that are a bit longer, all of which benefit me. The meditations that they have also are of different styles. You can try different forms of meditation. I particularly like having a guide for my meditation. It just helps me stay focused, helps me stay on track and I'm able to derive all those regular benefits of meditation and keep the practice up on a regular basis, if you want to try Headspace, you can go to headspace.com/specialoffer. And if you do that, you'll get a one month totally free trial. And with that, you'll get all of Headspace's meditations, the full library of meditations. You just go to headspace.com/special offer, and you get all of their meditations for one free month and you get to try it, if you don't like it, you can stop. But I think you will enjoy it.

00:08:22 Main Drivers of Feelings & Performance

I certainly enjoy meditation and we know that it's very beneficial for all of us. If you're somebody who cares about your immediate and long-term health, and if you're somebody who's interested in performance of any kind in work in relationships, et cetera, today's topic I believe is among the more important ones for you. Of all the topics I could cover, this thing that we call sense of self, which is also called interoception has perhaps the most foundational level of importance for all that. We feel all that we do and all that we are capable of doing. In fact I will go so far as to say that interoception or our ability to sense our inner real estate is right there next to sleep. And perhaps one other feature of our health and bodily function that primary early determine how good we feel in the now in the short term, and in the longterm, and sets the stage for everything we are capable of doing. And if we don't take care of this thing that we call interoception, just

like if we don't take care of sleep, we cannot perform well and we will not remain healthy. Interoception and sense of self are essentially the same thing, I will use those terms interchangeably, at least for sake of today's discussion. And I promise that if you can learn a little bit about the mechanisms of self sensing, of understanding what's going on in your internal milieu, as we say your internal environment, you will position yourself to do some very simple things that can lead to outsize positive effects on everything from sleep to body composition, to mental focus, to mood, your ability to regulate stress, and indeed even your ability to heal and recovery from injuries of different kinds, brain injury and bodily injury. So sense of self is absolutely crucial. It's sometimes called our sixth sense, right alongside the other five senses like hearing vision, touch, taste, smell, et cetera, but sense of self is different. Sense of self is really about what's going on internally within the confines of our skin. And it involves two key features that if you can understand those features, and you understand what modulates or changes, our ability to sense those features, there are a lot of things that you can do in terms of how you structure your nutritional practices, how you relate to your exercise practices, perhaps even certain things that you take in terms of supplementation that can basically make you feel better, more alert, and more capable for everything. I don't think that's a hyperbolic statement, I, in fact, I know it's not a hyperbolic statement because we have a system in our body that connects our brain to all of our bodily organs and connects all of those bodily organs to our brain. And that communication between brain and body in both directions creates a situation where either we are positioned to do things well, or we are positioned to do things poorly. So I really want to dive in and dissect, what is this system of brain, body communication? What does it look like? What are the actual neurons and connections? And as I do that, I promise that I'm going to place protocols, tools that you can apply in order to make sure that those neurons and connections are working optimally. So let's begin by talking about what system communicates the

00:11:45 Brain-Body: A Mechanical & Chemical Dialogue

brain to the body and the body back to the brain. The system that's most often associated with this is our 10th cranial nerve called the vagus nerve. The word vagus relates to the word vagabond, which to wander, and indeed the vagus nerve is a vast, enormous wandering set of nerves, so it's not one nerve. It's not like one fiber, one axon. As we say in the nervous system, we have these wires, we call axons that let neurons

communicate. It's a bunch of neurons and a bunch of wires that go everywhere, so where do they go? Well they leave the brain, and the brain stem, the brain stem is kind of the back of your brain. If you touch the back of your neck, it's about three inches deep to where you're touching. The neurons that are there send information into the body to control your bodily organs, how fast your heart is, beating how fast you're breathing, how fast your digestion is occurring. Even things like whether or not you are going to secrete so-called killer cells, your immune cells from your spleen to go ward off bacteria. Now the neurons there don't know what to do unless they receive information about what's going on within the body and within the body, your heart, your lungs, your diaphragm, your gut, so everything from your intestines to your stomach, et cetera, and your spleen or sending information also up to the brain. So as I mentioned before, it's a two-way street. So the vagus nerve is a very important nerve, but just by saying vagus nerve, it sounds like a singular. It sounds like one thing, but actually what we're talking about is a series of super highways, it's like Google maps, it's got stuff going everywhere with alternate routes, communicating back and forth. There are two fundamental features of what's going on in your body that need to be communicated to your brain, these neurons in your brain stem in order for your brain and your body to work together correctly. And the two types of information are mechanical information. So things like pressure, things like lack of pressure and chemical information, whether or not your gut is acidic or whether or not it's not acidic, whether or not you have some sort of pathogen, you know, something that you ate or that got into your body somehow and is making you sick or whether or not you don't have a pathogen in your body. So you've got mechanical sensing and chemical sensing. So when you think about your sense of self and your ability to understand what's going on in your body, if you feel good, or if you feel bad, your sense of self is dependent on these mechanical phenomenon and these chemical phenomenon. And for every organ in your body, whether or not that's your heart or your lungs or your spleen, both the mechanical information about that organ for instance, is if your gut is full or empty, whether or not your heart is beating fast or beating slowly, that's mechanical, and chemical information, whether or not your gut feels nice, and whether, you know, when I say nice, I mean, whether or not it has a balance of acidity and alkalinity, that feels right to you or whether or not your gut feels off, it doesn't feel quite right. That's chemical information. If you are not getting enough oxygen and levels of carbon dioxide and other gas go up too high. So your lungs can register that and that chemical information is sent to your brain. And then your brain does certain things

actually really encourages you to do certain things in order to adjust that chemistry. So the first principle that everyone should understand about their sense of self is that they are sensing mechanical and chemical information about every organ in their body, except for one, and that's the brain. Your brain actually doesn't have pain receptors. It doesn't even have touch receptors. The brain is a command center. It helps drive and govern changes in the organs of the body. But your brain doesn't move, at least not much. It can move a little bit fluid moves within it. But as long as you're healthy, it's not moving that much. Your brain has no sensation of its own, in fact, when they do brain surgery on people, they will the size or put some anesthesia on the scalp. They'll cut away the skin there so that people don't feel anything. They'll use some anesthesia they'll peel back the skin and then they'll use a, let's call it what it is, it's a bone saw. And they basically saw open a little window in the skull. I've actually done this before and seen this before. I've done this many times before, and once you're inside the brain, you can put electrodes in there and you can put various things in there, of course, all for therapeutic purposes. And you do that without any anesthesia to the actual brain tissue, because it has no receptors to sense anything. It doesn't have pain receptors. It doesn't have pressure receptors. None of that, when you have a headache in your head, feels like it's too much pressure, well that's because of here's that lie outside the brain. So your organs are different. They need to tell your brain what's going on. And there are ways that you can control the mechanical and the chemical state of your organs in ways that are very powerful, and this is crucial to do, because if you can properly regulate the mechanical and chemical environment of your body, your brain functions better. This is absolutely clear from data that if your gut is healthy, if you get the alkalinity right, the acidity, right, and if your spleen is healthy and happy, and if your lungs are working properly, not just breathing and pumping in and out air, but you're breathing at the right cadence for a particular activity, then your brain will function better. So let's talk about how you can adjust the mechanical and chemical environment of your organs in order to make your brain better and how your brain can make the mechanical and chemical environment within your organs function better. For instance we're going to talk about how you can change the chemistry of your gut in order for your brain to be able to focus better, think better, remember better and sleep better. And we're going to talk about how you can change the chemistry of other organs in your body, such that your immune system will function better than it would otherwise. And you can actually heal faster from small cuts and

00:17:50 LDB (Lung-Diaphragm-Brain) Dialogue

bruises, but also injuries of any kind, even major injuries. So as I mentioned before, we've got these organs, the heart, the lungs, the diaphragm, and I'll explain what that is, the gut and the spleen. And the spleen is this immune organ. Let's take one example of these and explain how mechanical and chemical information from this particular set of organs communicates to the brain and how that changes how our brain works. And the organ I'd like to focus on first are the lungs and the diaphragm. So we're all familiar with our lungs, these two big bags of air, but they're actually not two big bags of air. They actually have little tiny sacs within them, actually millions of little sacs called the alveoli of the lungs. The alveoli of the lungs are like little tiny balloons throughout our lungs, and the more of those balloons, we have, the more air that we can actually contain. So we are not too big bags of air in there, our lungs, we actually have millions and millions of little tiny bags of air within those lungs. Those little bags of air can fill up or they can deflate, right, just like your lungs overall can fill up or they can deflate. The diaphragm is a muscle, it's kind of shaped like a dome. So it's kind of a, you know, think about a basketball or a soccer ball that has most of the air pushed out of it. And so it's kind of crescent shape or dome shaped, and it sits below our lungs and the way the diaphragm and the lungs work together is very interesting. The diaphragm is actually skeletal muscles. So it's just like a bicep or a quadricep. And the fact that it is skeletal muscle is important because it has a unique property, which is that you can control it voluntarily. You can decide to take control of your diaphragm by just consciously deciding you want to breathe in a particular way, just like you can take conscious control over your legs. They will work just fine, if you're not thinking about them, as you walk as provide, you already know how to walk, but at any moment, you can decide to change the rate of your walking, your so-called cadence of walking. So the diaphragm as a skeletal muscle also has that property, the diaphragm moves up and down, depending on how you breathe, or rather, I should say how the diaphragm moves up and down determines how you breathe. How you breathe is also dependent on little muscles that are between your ribs, the intercostals and other muscles, if you're a martial arts fan that Bruce Lee was famous for having these very pronounced intercostals from doing all sorts of, you know, bridging exercise, et cetera. But those are the muscles. And we all have them, even if some of us, most of us don't have, intercostals like Bruce Lee. So when you breathe a

couple things happen, but let's talk about the mechanical things first. And then let's talk about how those mechanical steps relate back to the brain and what that does for the brain. And I can promise you that if you develop an awareness of these mechanical changes, you do not have to go through extensive breathwork practice or do extensive breathwork. You will immediately believe it or not develop a sense of your breathing self of your lungs and diaphragm. It takes no practice, but once you do it, you will forever be changed in terms of your awareness of your breathing and your ability to leverage your breathing. Kind of like the steering wheel on a car in order to shift your brain in the direction that you want to go.

00:21:00 Protocols 2, 3, 4: Control Heart Rate With Breathing

So it's a very powerful system. And the way it works is the following. And this will also incorporate the heart, so, and by the heart, I don't mean it in the emotional sense. Although we don't rule out emotions here at the Huberman Lab podcast, we like emotions, but I'm talking about the heart as an organ, as a beating organ, that circulates blood. So when we inhale, these little sacs in our lungs fill up and our lungs expand. And when we do that, we take up space in our thoracic cavity and our diaphragm moves down, okay. When we exhale, the diaphragm moves up, the lungs get smaller, okay? So inhales, diaphragm moves down. Exhales, diaphragm moves up. This actually controls our heart rate, but it does it by changing the way that our brain works. And it works in the following way. So when we inhale, our lungs fill our diaphragm moves down. Our heart actually has a little more space because the diaphragm's moved down. So the heart gets a little bit bigger, physically bigger, not in the emotional sense, but physically bigger. And as a consequence, whatever blood is in the heart flows at a slower rate because it's a larger volume, so bigger volume heart, same amount of blood inside the heart means slower flow. Okay, sort of like expanding a pipe. The brain registers that because there are a set of neurons in the heart called the sinoatrial node. It sends that information to the brain. That information is registered by the brain and the brain sends a message back to the heart to speed the heart up. So every time you inhale because of these mechanical changes in the diaphragm and lungs, and because of the mechanical changes in the heart, your brain sends a signal to the heart to speed the heart up, so if you do long inhales or you inhale more vigorously, you actually are speeding your heart up. Now, of course you have to exhale as well. But for instance, if I were to inhale very

long like [inhales heavily] the entire time my heart rate is increasing. And then if I did a quick exhale, [exhales quickly] something else will happen, but if I kept doing that, [inhales heavily, exhales quickly] my heart rate would increase. It's not going to increase linearly and forever, but it will increase with each inhale. Or I can simply make my inhales more vigorous. [inhales quickly] And my heart rate will speed up. This is an autonomic and automatic relationship between the diaphragm, the lungs, the brain, and the heart. Now, if inhale speed the heart up, what happens on exhales? When we exhale, the diaphragm moves up. It's a little counterintuitive, but you can kind of think about it as like pushing the plunger on a syringe, right? When you exhale, this thing moves up and as the diaphragm moves up, the heart has less space. Meaning it gets a little bit smaller, which means that whatever volume of blood is inside the heart moves faster, through that smaller volume, that information is sent to the brain via these collection of neurons called the sinoatrial node for you aficionados. The brain then sends information via the vagus nerve back to the heart, to slow the heart down. So while inhales speed up the heart, that's the net effect exhales, slow the heart down. And the reason they slow the heart down is because of a register in the change in mechanical pressure between the diaphragm, the lungs and the heart. So this is to me, the simplest and most straightforward example of how the brain is changing the way our organs work, our heart in this case, according to changes in mechanical interoception. Now, we're not always aware of this, some of us are aware of it, some of us aren't. If you do it right now, you will be aware of it, so you can try this. You can basically, this is an experiment or an example in interoception, in sensing one's self. So if you inhale, doesn't matter how long you inhale. I'll do it for a couple seconds [inhales quickly] and then exhale twice as long. [exhales slowly] Nose or mouth, doesn't matter, the entire time that you're exhaling, you're slowing your heart down. So just as a car has an accelerator and a brake, or you can slow a car by coming off the accelerator. When you exhale, you're effectively coming off the accelerator, or if you want to think about it differently, you're hitting the brake, you're slowing down your heart rate. Now, normally your heart rate stays in more or less the same range for a given activity because you're inhaling and exhaling. But this is just a simple way of showing that mechanical changes in your viscera can change the way that your brain works and then your brain changes the way that those viscera work. And it's a very concrete agreement, it's like a contract between the organs of your body and the brain. In fact, you can think about this contract in more detail, and you can leverage this in a very powerful way to set the conditions of your mind. If you want to be more

calm, emphasize exhales, and the simplest way to do this. I've talked about this many times before, but if you haven't heard me say it, this will become immediately clear is to emphasize exhales through what's called a physiological sigh. Two inhales, could be through the nose or the mouth, but ideally through the nose, so [inhales quickly twice] so followed by a long exhale. [exhales slowly] Those double inhales are kind of important because what they do is they maximally fill all those little sacs in your lungs, and then when you breathe out, you're exhaling as much of the so-called carbon dioxide in your system as possible. We'll talk about carbon oxide in a second. So the fastest way to calm down is to emphasize exhales. When you make exhales longer, you're slowing your heart rate, you're calming down. You don't need any sophisticated training. You don't have to do this for minutes on end. You don't have to do anything. You don't even have to call it breathwork. It's just respiration, and in fact, you do this every night. When you go to sleep and carbon dioxide builds up too much in your bloodstream, or if you hold your breath or something, or you watch an animal or a small child that sleeping, they will occasionally do these double inhale long exhales it's way of slowing the heart down and eliminating carbon oxide. The opposite is also true. If you inhale deeply or vigorously and then exhale less long or less vigorously, you will increase your level of alertness through these purely mechanical aspects of your interoception. So for instance, if I were to take a big deep inhale [inhales deeply] and then a short exhale, [exhales quickly] and then another one, a big inhale, [inhales deeply] short exhale, [exhales quickly] It only takes two or three of those before you start to feel more alert. And that's because your heart rate is increasing. And actually if you keep doing that for 25 or 30 breaths of inhale deep short exhale, you will start to secrete a lot of adrenaline. This hormone that comes from your kidneys and from your brainstem make you feel really alert. You will actually feel as if you've had a cup of espresso. So you will immediately wake up. And there's an intermediate form of breathing, which is sometimes called box breathing, but it's really equal inhale and exhale duration. And these, it basically goes like this. You're you're going to inhale, so do this for maybe two, three seconds inhale, [inhales] then hold, okay, two, three seconds. Then exhale, two, three seconds. Then hold two, three seconds. Most often people forget to hold. So it's inhale, hold, exhale, hold for equal or more or less equal durations, could be one second, could be two seconds, could be three seconds. Most people find that when you get out past five seconds, they start to struggle to maintain the so-called box breathing. And most people can't consciously box breathe for too terribly long without having to think about it.

But the point here is that through purely mechanical means changing the way that you breathe, emphasizing inhales or exhales, or keeping them the same will change the way that your brain works, how alert you are and how well you function in anything. And again, this doesn't mean that breathwork has no value. It's just simply to say that long extended protocols of breathwork are simply, they are truly simply just an exploration of this fundamental relationship between the mechanics

00:29:08 Sensing Lung Pressure: Piezo Receptors

of your internal organs and your brain and how your brain controls those internal organs. Now you might ask, well, how is this pressure known? How does the body actually know how full the lungs are, now? This is an answer that's more for the aficionados out there, but I've had a few requests, or I should say thousands of requests for more in-depth science, so if you're not interested more in depth science, just this will allow you to tune out now for maybe just 10 seconds, and if you are interested, pay careful attention, there is a set of receptors which are called piezo receptors, P-I-E-Z-O piezo receptors, piezo means pressure. And these were discovered a few years ago by a couple of different laboratories, but one of the main ones, one of the main laboratories that discovered these piezo receptors is the laboratory of Ardem Patapoutian. I love saying his name, even though I'm probably pronouncing it, he's a friend and a former colleague when my lab was down in San Diego, he's at the Scripps Institute, he's a Howard Hughes Medical Institute investigator, which basically means that he's a total stud of science and has made many important discoveries. The piezo receptors line many tissues, and inform the brain about pressure in those tissues. But the lungs have a particular category of piezo receptors called piezo two receptors. And as you fill your lungs and these little sacs of air, the alveoli fill, the piezo two receptors because of the way they react to that filling send information by way of a bunch of neurons, a bunch of wires up to the brain and tell you how full your lungs are, so that's the kind of mechanistic detail. If you want to learn more about that, you can look up our Ardem's lab at the Scripps and the beautiful work that they and other laboratories are doing on piezos, piezos are pretty cool.

00:30:54 Carbon Dioxide, From Air to Blood

I think I also just like saying piezo, so that's why I brought that up as well. So mechanical

sensing of the lungs, heart and diaphragm. And now let's talk about chemical sensing because there's carbon dioxide and there's oxygen. And this is really simple. You have oxygen and carbon dioxide and you need them both. I sometimes hear people talk about carbon dioxide is this bad thing and oxygen, it has a good thing. You need them both, and you need them in the appropriate balance. You have a collection of neurons in your brain that register when carbon dioxide levels get to a certain point in your bloodstream. When that point, that threshold is reached, these neurons fire, and they cause you to breathe sometimes called the gasp reflex, it just makes you want to inhale. And as a consequence, you bring in more oxygen. Okay, so we don't really breathe to get oxygen. That's a by-product of inhaling to eliminate carbon dioxide. You don't want carbon dioxide levels to go too high. In fact, if you want to freak somebody out and we do these in experiments, and I don't recommend you do this, you just increase the levels of carbon dioxide that they inhale, and the brain will go into an almost immediate panic response because the health of all our tissues depends on keeping a nice balance between carbon dioxide and oxygen. You don't want carbon dioxide levels to go too high. So the impulse to breathe, if you're under water, or if you hold your breath is triggered by these neurons and the triggering of those neurons comes from elevated carbon dioxide in the bloodstream. And for those of you that don't quite know how to conceptualize the relationship between bloodstream and breath, I do think it's important. And maybe you remember this from high school biology, but if you don't, I'll make it clear for you now, it's very easy. You inhale air and that air and the oxygen molecules in that air actually move from your lungs into the bloodstream because these little alveoli of the lungs, those little sacs of air are in there, they basically have a lot of little micro vessels and capillaries, little tiny, basically blood vessels, essentially, although they're mostly capillaries, micro capillaries are the little tiny ones, that line them, so there's actually an interface and opportunity for air and molecules within the air to pass into the blood and then they move in your bloodstream, and when you exhale, the opposite is true. So you can move things from the air, into your bloodstream or from your bloodstream into the air by way of the lungs, and there's a lot more detail to it. And I'm sure those of you that are experts out there. If you want to put some stuff in the comments, maybe a little bit of a kind of intermediate tutorial, you might even entitle it, intermediate tutorial. If you know a lot about this, just I'll check it, but make sure you get the details, right. Make sure you know the process. And I find that for people that are interested in understanding how breathing really works, it's really nice to think about the relationship between the heart

and the vascular system, the blood and the air system, the respiration system, and breathing, because those two things are very, we say, they're interdigitated, they're interwoven with one another. So how does this work, well, carbon dioxide is too high, you breathe in, you inspire, you,

00:34:02 Protocol 5: Alert While Calm

inhale you off as a consequence, when you exhale, you offload carbon dioxide. There's a really cool way that you can explore this chemistry of your breathing and your bloodstream and the way that your brain works in ways that can really benefit your health. And it works the following way. You want to essentially sit or lie down. It doesn't really matter. You definitely don't want to be anywhere near water, not a bathtub, not a hot tub, not a, you know, not a cold dunk or something. In fact, don't even be in a puddle. And what you want to do in this case is you're going to breathe in deep. So that's going to increase your heart rate and then exhale passively by just letting air fall out of your mouth. So it will look something like this. [inhales vigorously, exhales passively] So it's you breathe in vigorously and then you let the air just fall out of your mouth. When you do that, what you're essentially doing is you're bringing in a lot of oxygen through that deep breath. And you're exhaling a little bit of that carbon dioxide. But if you were to repeat it 25 times, maybe 30 times, it doesn't matter if it's 25 or 30, somewhere in there, you would essentially start bringing in a lot of oxygen and blowing off or exhaling a lot of carbon dioxide. So you're actually going to change the chemistry of your internal landscape, and you can then sense it. You can interocept what that is like. And there are some really interesting reasons for wanting to do that, so I'm not going to do all 25 or 30 now, maybe do five or 10, so you can get a sense of what it looks like, so that it's clear. I'm going to essentially demonstrate now, so it's inhale, [inhales vigorously] exhale through the mouth, [exhales] I am inhaling the nose, [inhales vigorously, exhales passively multiple times] So it's essentially, excuse me, a two second or so inhale and then a one second or so exhale, and as I was doing that, I can kind of feel my face get flush and my body is heating up and my brain is heating up, what's happening there? Well that pattern of breathing is increasing levels of adrenaline in my brain and body, and I'm getting more alert. Then after 25 or 30 of those, you exhale all your air. [exhales deeply] You dump all your air. You can do that, your nose or your mouth. And then you hold your breath with your lungs empty for about 15 to 30 seconds. Now, for those of

you that want to explore this, and please be careful as you explore this, don't do anything stupid, like do this while you're driving or something like that. You can exhale all your air and what you'll find then is you can hold your breath for a very long time. And the reason you can do that is because you've blown off all the carbon dioxide or most of the carbon dioxide in your bloodstream. So you shifted the chemistry of your blood by breathing in a particular way. And by doing that, you are no longer triggering these neurons that cause the gasp reflex or the reflex to breathe. Now, of course you have to breathe sooner or later but what you'll find is if normally your ability to hold your breath is a minute or so before you really feel that gasp reflex kick in, you might find that you can go 90 seconds or two minutes. And with some practice, people find that they can start holding their breath for three or four minutes or longer. This is actually how free divers do what they do. I do not want anyone free diving. If you're going to learn free diving, please learn it from an expert. Many people die trying to teach themselves out of free dive or trying to teach their friends at a free dive when they don't know what they're doing. This is not what this is about, don't again, don't do this anywhere near water, but it is a very interesting exploration of how you can shift the chemistry of your bloodstream by modulating your air by modulating the mechanics of your diaphragm and lungs and thereby shift the way your mind works, your brain. And in fact, what you'll notice is that even though during that 25 or 30 breaths, [inhales and exhales quickly] you'll feel very alert, when you exhale all your air and you're in the breath hold, you will feel very alert, but very calm. Now this is interesting because it's a state that we all sort of want to achieve alert, but calm, but have a hard time achieving. And so for those of you that have a hard time obtaining focus for sake of work or focus for sake of anything I should say, and when you are able to achieve focus, it's through the use of things like stimulants, or you feel like you have to have a cold shower or ice bath, or you have to have four espresso in order to be alert, but then you're too alert, you're jittery. You can't focus. This pattern of breathing can lend itself very well to entering states of alert, but calm for the fall, the 10 or even 20 minutes that follow that breathing. And then you could repeat it if you want. So it's a very useful practice to explore. Some of you may be familiar with this practice and so-called Wim Hof breathing. Wim Hof is a practitioner of what's called Tumo breathing. Tumo breathing has been around for centuries. And for those of you that are familiar with breathwork and yoga practices, I acknowledged that nothing I just described is new based on science, however, the science informs why those practices work. And just as a little mini editorial, I just want to emphasize as well.

That one thing that this podcast is really about is trying to remove fancy nomenclature, whether or not it's yogic nomenclature or scientific nomenclature so that people can access protocols. Because the moment we start naming things after people or calling them Tumo et cetera, I have no problem with that, but it doesn't inform how the practices are done, nor does it inform the underlying mechanisms. So here I'm trying to teach you the mechanisms. And as a final point to that, the most powerful form of breathing is the one that takes into account the fundamental mechanisms that increase heart rate, that exhales decrease heart rate, and that carbon dioxide and oxygen relate to the bloodstream and the brain in particular ways, once you understand those components, then you can create your own so-called breathwork practices. You can breathe in the ways that best serve you, as opposed to thinking that one protocol is the best or holy protocol for everything, because it's simply not. As a final final point, I want to say that as you shift the way that you breathe, whether or not you're showing off more carbon dioxide or bringing in more oxygen, you are fundamentally changing the chemistry of your internal milieu have your body, and that has been shown to have important effects on the way that your immune system functions and the way that you deal with inflammation and all sorts of different sort of things that can enter your body and cause problems or conditions of stress, et cetera. So I will explore that further as the episode goes on, but I want to move on to just touch on one other aspect of reading, that's purely mechanical, which I think is very interesting and important, which relates to a particular reflex

00:40:50 Baroreceptors: Hering-Breuer Reflex

that you're going to be very familiar with in a second. And that can serve you very well in times of extreme stress. The reflex I'm referring to is something called the Hering Breuer Reflex. I'm not going to go into details about how the Hering Breuer reflex works, but it has to do with particular classes of neurons and cells that are called a Baroreceptors. Those are basically pressure receptors, they sense pressure. And basically what the Hering Breuer reflex is about is that when your lung is inflated, your desire to breathe is reduced. So you can try that right now, you can inhale [inhales] huge big thing of air. And hold, okay? Your desire to breathe will kick in later than were are you to exhale all your air and hold your breath. When you exhale all your air and your breath, unless you've done the sort of protocol I described a few minutes ago of doing a bunch of inhales and

exhales first in a very deliberate way, you will feel empty. Those Baroreceptors are going to be firing like crazy saying, there's no pressure in here, there's no pressure here, I got nothing in here. You need to breathe, you need to breathe in, the gasp reflex will kick in sooner. You can apply that in all sorts of situations related to exercise, related to modulating stress, et cetera. So the Hering Breuer reflex is a very powerful one. This is why you take a big deep breath before you go under water. [inhales heavily] All right, you're not going to exhale all your air and go under water. If you were to exhale all your air and go under water, you would absolutely feel the need to come up sooner for a breath of air than had you a full tank, so to speak a full of lungs full of air. And this is also the way that people teach themselves to feel comfortable under water. So when you learn how to swim, you learn how to swim both by having air in your lungs while you're underwater and no air in your lungs while you're underwater. In any event the Hering Breuer reflex is yet another dimension to the way that mechanical pressure influences

00:42:47 Gut Volume & The Desire to Open Your Mouth

your brain's decision-making, about what to do with your body, in this case, whether or not to breathe. So now I want to shift away from breathing and diaphragm and lungs and move toward another organ within our viscera, which is our gut. So this includes our stomach and our intestines, our esophagus and so forth. It's been said before, both by me and by others that we are, but a series of tubes, and indeed that's true. Believe it or not, every system in your body is a tube. Your brain is actually a tube that connects your spinal cord, which has also a tube. You started off as a tube, you were like a churro. You know, those churros I don't know if you're not familiar with churros, they're like donuts that are shaped like a tube. That's essentially what you look like early in development, not long after conception and the front end of that churro grew and grew and grew, but you always maintained a hollow through that tube. That's why you have what are called ventricles, gaps or a space in your brain and spinal cord that run the length of your brain and spinal cord and fluid, cerebral spinal fluid, and other things move through that space. We're going to return to the ventricles later, they are very important. They're just space filled with fluid, but they do a lot. Similarly your digestive system starts with the tube at your mouth and of course goes down through your throat. And then you've got all the elements of the stomach and the intestines, and then it comes out the other end. So you are, but a series of different tubes, your vascular system, a series of other tubes. So

you're tubes. The way your digestive system works is to communicate to your brain about the status of the mechanical pressures along this tube, so within your stomach and your intestines, et cetera, and the chemical status of that tube at various portions within that tube to inform your brain about how your brain should control that tube. So let's start with the mechanical sensing of your gut. If you drink a lot of fluid, or if you eat a lot of food, your gut will fill up, your stomach will fill up with food. Now it gets digested there. It gets digested elsewhere along your digestive track too, of course but it starts getting digested there because along this tube, you have a series of what are called sphincters, which basically are like little draw pulls. Have you ever had a laundry bag, which has a drawstring on it? You pull it and then it cinches shut, and then you can open it again, that's what those are. Those are sphincter openings and you have them in your throat, you have them along your digestive tract, all the way to the end. Food will enter your gut. And if there's a lot of that food, pressure receptors, some of which are these piezo receptors will communicate to the areas of your brain that are involved in feeding, and we'll say, don't eat anymore. You don't need to consume anymore, now, some people bypass that these, I guess they have these like hotdog eating competitions. I'm always struck by how some of those people are like, seem to be rail thin, but they actually train for those competitions by ingesting large volumes of water, actually a very dangerous practice. You can actually kill yourself by drinking too much water, and you can kill yourself by ingesting too much of anything, really to expand your gut, not a good practice, not a big fan of those competitions. But even if you're one of those people or you're the world heavyweight champion of them, they are informative toward what I'm talking about now, which is that as you expand the gut, a signal is sent by neurons, literally nerve cells that are in the gut to the brain, stem up to the areas of the brain that are involved in feeding, I did a whole episode on feeding. You can find on "Feeding, Metabolism And Hunger." You're welcome to listen to that episode, if you like, and we'll shut down the neurons that drive the desire to put more stuff in your mouth. That thing that people say sometimes on well in this country frequently after Thanksgiving meal, I can't put another bite in my mouth. Literally they shut down some of the basic movements of the musculature to take another fork bite. I know it sounds crazy, but they can actually control your brain. So your gut is so full that it's controlling your brains, such that this action of spooning food towards your mouth is actually inhibited. It's made more difficult or less likely to occur. It's incredible. The converse is also true, when these piezo receptors signal to the brain, that the gut is empty independent of your need, your actual

need for food. There's a signal that sent to your brain that says gut is empty and neurons get stimulated in areas like the arcuate nucleus and these areas of the hypothalamus and et cetera, that drive the desire to make this action, to open the mouth and to put stuff in it in particular food. So when you find yourself at the refrigerator or you find yourself almost, you know, manically trying to get food of different cons, you're not even thinking about what you're eating, because you're so hungry, in part that's because the lack of food in your gut has sent that information to your brain and is driving particular fixed action patterns that are associated with eating, in fact, one of the first things children learn how to do is open their mouth when something is presented to it. And then they learn how to move a spoon or a fork. They're not very good at it, at first, they get all over the place, but eventually they get good at, or at least most people get good at if you watch how people eat, you know, it's kind of very variable out there. In any event, this is a purely mechanical phenomenon. And this purely mechanical phenomenon is driving our brain

00:48:18 Protocol 6: Enhancing Gut-To-Brain Communication, Fasting

to drive certain behavior. You can get better at registering sense of fullness or lack of fullness in a very particular way. Some people have a very keen sense of how full or empty their stomach is, so if you've eaten anything, even if it's a small volume of food in the last hour to three hours, it's actually a worthwhile practice to take a few moments, maybe 10, 20 seconds, and actually just try and concentrate on sensing the neurons in your gut and how full you are, like for instance, I ate a few hours ago and then I had a little snack about 30 minutes ago or so. And my gut feels neither terribly full nor terribly empty. It's kind of, I would put it kind of like 30, 40% okay. So by just taking conscious awareness of how full or empty our gut is at various times between meals, after a meal, before a meal, you can very quickly develop a sense of how full or empty you are. Now, what's the consequence of that? The consequence of that is actually rather interesting. It's been shown that the consequence of that is actually that you can better override the signals of these piezo receptors and gut fullness or emptiness. So for those of you that find that you eat kind of compulsively or non-consciously, or subconsciously, I should say, probably have to be conscious enough to be awake to eat, but subconsciously you just find yourself eating and here I'm describing myself, I'm like, I'm a drive by blueberry eater. If there's a bowl of blueberries, every time I walk past it, I sort of have to grab a

handful of them and pop them in my mouth, but if you develop this sense of how much mecho-pressure, it's not really word, but how much mechano-sensation is in your gut, very quickly, you can learn to override that. You might ask, why would I want to be able to override whether or not my stomach is empty or my stomach is full? Well, there are many reasons to want to do that. Many people right now are interested in so-called intermittent fasting. They're doing fast of anywhere from 12 to 16 hours, every 24 hour cycle, that's actually what my practice is. I do that on a regular basis, sometimes the, I eat breakfast, but normally I pushed breakfast out to about 11 or noon, or sometimes a little later, some people are doing longer fast, and there are really wonderful data publishing excellent journals from my colleagues Satchin Panda at the Salk Institute Of Biological Studies. And of course from other laboratories showing that intermittent fasting can and will have some positive health effects on things like liver health and brain health and other aspects of health. Whether or not it's the best form of dieting for the sake of losing weight, that's very controversial, but it's clear that having a period of fasting every 24 hours or perhaps even longer from time to time can be beneficial because it stimulates what's called autophagy, the clearing away, or the body's ability to eat certain dead cells, so called senescent cells, and for many people, they struggle with fasting because they feel they have a very keen sense of their stomach being empty. And they feel as if they have to eat. And in a kind of counter-intuitive way, there's some data that indicate that being able to sense whether or not your gut is full or empty, and just the knowledge that that's communicating information to your brain about whether to not to eat or not just that awareness, that understanding allows them to override the signal. They think, oh, you know, I'm not actually in need of nutrients right now. It's just that my stomach is empty. And these piezo receptors, and some other ones that I'll tell you about in a moment are signaling to my brain that it's empty. I don't actually need food, it's just, it's just that my brain is reacting

00:51:50 Intestines, Fatty Acids, Amino Acids & Sugar

to the fact that my gut is deflated, so to speak or a smaller, doesn't have food in it. So there are other ways that our guts communicate with our brain, it's not just our stomach talking to our brain. It's also our intestines talk to our brain. The Liberles Lab the guy's name is Steven Liberles, he runs a lab at Harvard Medical School, it's a terrific lab, does excellent work on gut, brain communication and other aspects of viscera brain

communication. They discovered a category of neurons called the GLP1R neurons, these are neurons that are basically in your neck, I mean, they're part of the nervous system, but they're, you can, they can be found near your neck. And those neurons send little wires down into the intestines and deep into the stomach, but mostly into the intestines and they sense stretch of your intestines. So this is pretty wild. These neurons sense how stretched out your intestines are and how fast things are moving through your intestines, slow or fast, or if there's nothing there. And then those neurons send another branch, they have a branch in one direction, senses what's going on in your intestines. And they have another branch that goes up from your neck in your brain to either trigger the desire to eat more or just stop eating. So these are really cool neurons and they're basically stretch receptors. They look a lot like the piezo receptors that we talked about before, so these GLP1R neurons are sensing stretch, so purely mechanical sensing. And in addition to that, the Liberles Lab discovered neurons that detect nutrients themselves. Now, the main reason why we need to eat is to bring nutrients into our body. And there is another set of neurons, those are called GPR65 neurons, if you want to know, but you don't have to remember that, do the same thing in terms of their connections. They send connections down into the intestines and into the gut, into the stomach, but mostly into the intestines. And then send that information back up to the brain as to whether or not there are certain kinds of nutrients in our digestive track. Now, these neurons are the ones to pay attention to if we're talking about chemical signaling and then in the next couple of minutes, I'm going to tell you about how you can understand hunger and had a modulate your hunger for the right foods, in fact, for healthy foods. The way this is done is by leveraging the activity of these GPR65 neurons, these neurons that sense nutrients, okay. They're telling your brain what's in your gut and intestines, and you have another set of neurons that were discovered by another guy he's out at Duke University, his name is Diego, excuse me, Diego Borges he's a wonderful scientist. He has a degree in nutrition, but also in neuroscience. And he found that there are neurons that line the gut, and those neurons in collaboration with these GPR65 neurons are sensing for three things, okay? So we say nutrients, which nutrients are they looking for? What are these neurons paying attention to? While these neurons are activated by the presence of fatty acids in particular, omega-3 fatty acids, sorts of things that come from fatty fish, oil, krill, certain kinds of animal protein, animal, and plant substances. You can look up what has a lot of omega-3s and those omega-3s make these neurons fire electrically like crazy up to the brain and make you want to eat

more of those things, but it turns out in pretty appropriate levels. These neurons also respond to amino acids. So when you eat a food, it's broken down in the gut, actually the way it's broken down in the gut is kind of interesting. Your gut basically cinches off a sphincter up top, cinches off a sphincter below it when there's food there. And then you have a series of smooth muscles that tumble the food and literally physically break it down. And then of course, enzymes come in and start digesting the food. And we're going to talk about digestion and how that's communicated to the brain in a moment. And for those of you with any autoimmune issues or digestive issues, this is going to be very important conversation. But meanwhile there are these neurons in the gut and as these fatty acids float out of the digested food, so literally fat molecules, and as amino acids are coming from the proteins as they're digested in the gut. And as a third food item, sugars are coming from the foods that we eat. These neurons will fire a lot to the brain that says, Hey, whatever you're doing up there, do more of it, okay? Now the sugars are a little bit cryptic because when I say sugars or I say amino acids, or I say fatty acids, this has nothing to do with taste. In fact, beautiful experiments have been done by the Borges Lab and by other labs showing that even if you numb the mouth, even if you gavage, which is a really, just a, it's a fancy word for basically tube feeding, you put a tube down into the gut, you just deliver the food to the gut. So you get no opportunity to taste, it sounds pretty awful. If you force feed by gavage, or you numb the mouth, these neurons don't care about the mouth. They only care about the nutrients coming from these foods. And then they signal to the brain, hey, do that thing, do that thing where you lift that object, we call a fork or a spoon, do that thing where you drink the milkshake,

00:57:00 Protocol 7: Reducing Sugar Cravings with Specific Amino Acid Nutrients

do that thing where you move your mouth like this, not talking, but do that thing where you swallow. So that's how the nutrients in our gut control us. And this is why for people that experience extreme sugar cravings, or even mild sugar cravings, replacing those foods with foods that have high levels of omega-3 or amino acids can produce sugar cravings. And I've talked about this on a previous episode, but if you didn't catch it, no big deal. I'll tell you right now that for many people, the solution to sugar cravings is to ingest a small amount, maybe a teaspoon or so of an amino acid called glutamine. And if you have really extreme sugar cravings, you can even mix that glutamine with a full-fat

cream, which actually makes it taste pretty darn good. And you drink that anytime you have a sugar craving or just a sip or two of that. And we find is that the sugar cravings disappear, because you're basically giving fat and amino acids to those neurons in the gut and in the intestine, that signal to the brain that you want more. Now, this doesn't give you a kind of runaway hunger for full fat cream. Although it will say when I was in high school for various reasons, but mostly because I liked the way it tastes. I was using half and half in my cereal. And I was waking up in the middle of night and drinking half and half, and that stuff tastes pretty darn good once you get used to the high fat content. Not something I do now. But the point is these neurons don't really know taste, they only know nutrients. And so you can work with that system if you crave sugar, and I do believe that most if not all of us should be trying to limit, if not eliminate simple sugars, as much as possible most of the time, then things like glutamine, things like high omega-3 foods, et cetera, maybe even want to supplement with fish oil or something similar to get omega-3s, there are other reasons for wanting to do that too, can be very beneficial. And here's what we're talking about is interoception, it's your ability to sense your inner real estate, but in this case, by way of chemical signaling, not by way of mechanical signaling. So now I'd like to talk about another aspect

00:58:58 Gut Acidity (Is Good)

of gut chemistry that has profound effects on the brain, as well as on the immune system. And for those of you with auto-immune conditions, or for those of you that know people with auto-immune conditions, this is going to be a very important discussion. Your gut needs to maintain a certain level of acidity or alkalinity, for those of you without any chemistry background, basically the low numbers on the pH scale, that means more acidic, the higher, the numbers, more alkaline, so more alkaline means more basic and acidic means acidic. And it has to do with whom hydrogen atoms and all this other stuff, but you don't need to worry about that right now. We're not going to pH your gut right now, but we are going to talk about the pH of your gut. Your gut needs to be more acidic than essentially all other tissues of your body in order to function properly, bacteria thrive in alkaline conditions. I think this is important for people to understand. People are always thinking, oh, you should be more alkaline being acidic, that almost sounds like being inflamed at well, you know, it's a complicated discussion, but I think the semantics can be confusing, sometimes you want your gut to be acidic. You may ask, well, why are

people taking antacids? Well, those antacids are there for a particular purpose to essentially combat acid reflux, which is the sending up of stuff in the gut towards the esophagus. And it can cause heartburn and things of that sort. And the way the antacids work is they essentially cause the sphincters above the gut to sinch shut, but they really are only dealing with a symptom, not the cause. So rewind, and about 10, 20 years ago, the discussion about gut acidity was quite a bit different than it is now in the scientific and medical literature. In fact, for many years long before, I'm going to say it here, people have been saying that it's important to maintain proper acidity of the gut, but the science and medical professions sort of looked at that as kind of a scance like, you know, what's going on there, I don't, I don't know that there's any evidence that that's actually true, there are communities of people that were prescribing, or I should say recommending that people take hydrochloric acid HCL and adjusting gut acidity that way. And it was kind of frowned upon, now in looking over the peer reviewed literature, it's clear that this business of trying to make the gut a little more acidic is actually one way in which people treat or try and ameliorate acid reflux. So it's kind of counterintuitive increasing acidity in the gut to try and reduce acid reflux, thought you're supposed to take antacids, well, the field has shifted quite a bit. And so we're going to review what it is to maintain the chemistry of the gut at a slightly more acidic level or a more aesthetic level, I should say, because it turns out that there are a number of things that are in gut are just call it what it is, it's gastric juice, sounds kind of gross. But gastric juices are actually powerful modulators of brain state. Put differently, one of the best things that you can do to have a healthy brain, a well-functioning brain and a healthy and well-functioning body is to maintain proper gut chemistry. And that's basically accomplished by getting the right level of acidity and alkalinity in your gut. Now this is not quack pseudoscience. This is not based on cleanses or anything of that sort. Well, we're going to talk about now are peer reviewed data

01:02:20 Improving Nasal Microbiome

in very high quality journals, like the Journal Cell, which is one of the three apex science nature, so, and journals of that sort, that point to the gut microbiome and its relationship to acidity of the gut and how the gut microbiome can help enhance auto-immune function and various other aspects of brain and body health. So within all the mucosal lining tissues of our body, we have what are called microbiota, little micro organisms that

we didn't make that actually come from our environment or our food and live inside us. And there are good microbiota and there are bad microbiota whether or not we have good microbiota or bad microbiota depends on one thing. And that one thing is how acid or alkaline the given mucosal tissue is. So we actually have a microbiome in our nose. And just as a very brief aside, because I'd be remiss if I didn't say this, if you emphasize nasal breathing most of the time, except when speaking or eating. And if you downplay mouth breathing, meaning you refrain from mouth breathing, especially in sleep, you improve the nasal microbiome. It gets better at fighting off infections. This was shown in a beautiful paper, published in Cell Reports last year. And that paper I should mention was performed in humans. So you've got a microbiome in your nose and my nasal breathing most of the time, not all the time. Cause there going to be times when you need to breathe through your mouth for whatever reason, hard exercise or eating or speaking, but by breathing through your nose, most of the time you are creating an additional layer of immune defense against particles that could get you sick. Whereas when you mouth breathe, you are taking down a layer of defense and you are putting yourself more at risk of infection.

01:04:13 Inflammation & Microbiome: Fiber vs. Fermented

This is what this paper shows. You also have a gut microbiome that is in your throat, in your stomach and in your intestines. And that gut microbiome is extremely powerful in regulating your mood and your immune function. Now, this is not something that you can sense directly. You don't know when you have a bunch of good microbiota or a bunch of bad microbiota because you can feel them moving around in there, actually that would be pretty awful, that would be pretty creepy feeling. Rather that according to whether or not your gut is alkaline or acidic in the appropriate ways, you will populate your gut with the appropriate microbiota. So you want your stomach to be pretty acidic, but other elements of your digestive tract are going to be more pH. And basically there's a gradient, meaning there's a low to high pH gradient along the gut. You don't have to know what the pH should be at any one given point, because you're not going to go and put microbiota at one location and not another. What you essentially want to do is create an environment where the proper can thrive, because when you do that, you greatly decrease what are called inflammatory cytokines. So these are things that are secreted both by cells, within the body and cells within the brain to impact brain health and brain

function and bodily health. They go by particular name, so there's something called TNF alpha, Tumor Necrosis Factor Alpha. It is inflammatory. It's not a good thing to have at elevated levels. You have something called Interleukin Six, IL-6 also causes inflammation, causes damage to tissues, not a good thing to have elevated for long periods of time. And then you have anti-inflammatory cytokines, things like Interleukin 10, which reduce inflammation. And there are hundreds of these, if not thousands of these different cytokines, some of which promote inflammation, some of which reduce inflammation. The simple way to adjust these things in the proper ratios is to adjust your gut microbiome. The best way to adjust your microbiome is to ingest certain types of foods. So there is a beautiful literature on this now, but the most important literature is the one that I referred to at the beginning of this episode, which is what to ingest and what not to ingest in terms of foods in order to create the best conditions in your gut so that you can create the best conditions in your brain and body. There was a study done by my colleague, Justin Sonnenberg at Stanford School of Medicine. Justin's actually my upstairs neighbor in the building at Stanford where I work and they explored how different foods or different diets, I should say, impact the gut microbiome and inflammatory markers. And this is a beautiful study because it was done in hundreds of human patients. These actually weren't patients that were sick, I should say human subjects that were otherwise healthy from a huge variety of backgrounds, so you had men, you had women, you had people of different races, different ethnicities. You had a huge range of backgrounds and they tracked all of that. And what they did is they explored two types of diets. One is a high fiber diet. So dietary fibers are non-digestible are only partially digestible carbohydrates typically. And they compared that to diets that were unchanged, except for the inclusion of a few, to a few more servings of fermented foods, each day, things like sauerkraut, things like kimchi, they even explored, it sounds pretty disgusting to me, but who knows, I've never tried it, which is fermented cottage cheese. And what they found was that after initial period of a few weeks, where they had people either eat a lot of fiber or eat one or two servings of fermented foods, they had those people ramp up their ingestion of either fiber or fermented foods, so they kind of ease them into it. As they went baseline then ramp up to the point where they were ingesting, you know, four or five servings of fiber or of fermented foods per day, which sounds like a lot. But for fermented foods, that would be, you know, four or five tablespoons of sauerkraut or kimchi. It's not quite, it's not like huge platefuls of fermented foods. And then they looked at a number of things. They looked at the

proteome, which is a kind of like looking at the genome, but a bunch of proteins that are made in the body. And they did this by fecal samples, by stool samples, and they did this by blood draw, which is great, it's a real power of this study. In fact, the most comprehensive study that I'm aware of. By looking at these different tissues across long periods of time, so many weeks, and then returning people to their, to the diet that they were on before they went into the study, they will were able to establish in a causal way, how ingesting fibers or fibrous foods versus ingesting these fermented foods on a daily basis could impact the gut microbiome and many inflammatory markers and many markers of immune function and auto immune function. And the takeaway message from this study is that the fermented foods far out performed the high fiber diet. In fact, the high fiber diet in some people was beneficial and in other people caused issues with inflammation. This is very different than what I was taught growing up and what many of us were taught. Interestingly they also observed that people that ate the high fiber diet had increases in certain enzymes that lend themselves to better digestion of carbohydrates. And I think there's an important insight to come from this. Nowadays we kind of live in the age of extremes where people seem to either want to be carnivore or like never ingest a vegetable, I hear they don't even like allow pepper, but they're not even allowed, you know, sauerkraut or something like very extreme or pure plant based, pure vegan or pure. So essentially pure carbohydrate or pure animal protein, very extreme. I'm an omnivore, I like to eat a mixture of different things at different times of days, but very extreme, but this is interesting because what this, what these data show is that perhaps ingesting a high carbohydrate high fiber diet, which is really what these, the high-fiber condition really was actually makes people better at digesting carbohydrates. This may explain why people who are used to a, kind of a more paleo type or carnivore type diet might eat carbohydrates and say, oh, that doesn't work for me, I don't feel good. It might also explain why people who predominantly eat plant-based foods and carbohydrate foods will try eating meat as an experiment, or because they lost a bet or whatever it is and they'll do or desperation, or they'll do that. And then they'll say, oh, I don't feel good when I eat meat. How good you feel, it seems how well you can utilize that food, and how much of that food you crave may be determined in fact, it appears is determined by your food eating history, the types of food you eat. And I think this might explain some of the divide and hopefully might bridge some of the chasm between these different groups that are saying it should be one way,

01:11:15 Protocol 8: Reducing Inflammation & Enhancing Brain Function w/Fermented Foods

or it should be another. But at the core of the study was the bigger message. The bigger message is that all of us should be ingesting on a regular basis, daily basis, two to four servings of fermented foods of different kinds. And why I say that is because the inflammatory markers went down, the markers of auto-immune disruption went down, and the chemistry of the gut therefore was adjusted in the appropriate ways. Now it's not to say that high fiber is bad or that fiber is bad, I don't want people to confuse this, but even though this is a discussion about interoception, about sensing the self. This is a subconscious mechanism by which the gut communicates to many organs, including the brain. And it's been shown in other studies also in quality peer review journals that when the correct gut microbiota are present and these inflammatory markers are reduced, cognition improves so ability to focus, ability to sleep ability to ward off infection and wound healing all enhanced, in fact, even in autism spectrum disorder, in people that struggle with various mental conditions or disorders of the mind improving the gut microbiome seems to have powerful effects on improving brain symptoms. Along the lines of auto-immunity, there are a number of conditions that we call auto-immune conditions, and we will do entire episodes about these going forward. But for people with so-called irritable bowel syndrome, for people with Crohn's disease, for people with leaky gut, Hashimoto's, which is a kind of an immune system self-attack on one's thyroid gland and things like eczema, skin conditions, adjusting the gut microbiome has been shown to be useful in positively adjusting the symptoms of all of those, will it fix those conditions entirely? Probably not.

01:13:10 Leaking Guts, Auto-Immune function & Glutamine

But can it have a significant positive impact on them? Probably, yes. There is one thing that's worth mentioning in that list, which is leaky gut, what is leaky gut. Here, we're talking about the guts, what is it to have a leaky gut, it sounds awful. It sounds like something sort of like leaking out the end of the tube, and it maybe that too, I don't know. But leaky gut is actually because, your gut is not a tube that's continuous, one cell it's actually made up of many cells and those cells form a barrier and they form what are called tight junctions. If you have two cells and you want to create a fence out of those

cells, you bind them together. The way that the body does this is to bind them together with what are called tight junctions, these are, they go by names like claudins and things like that, if you want to look them up. These tight junctions form a nice barrier, like a cyclone fence, that things can't get past, but like a cyclone fence only molecules of a certain size can go through those holes. So you're not going to pass a soccer ball through an intact cyclone fence, but you could pass for instance, a feather through that fence. So leaky gut is when the conditions in the gut are too alkaline or the gut microbiota are off in the gut, meaning microbiota that like alkaline guts are living there. And those tight junctions can't function at that particular pH and you create little holes in that fence. And then what happens is when you ingest foods, some of those foods literally leak out of the gut and into the extracellular space and into the bloodstream. And because foods include proteins and antibodies react to proteins, what ends up happening in leaky gut, and the reason we talk about in auto-immune conditions is that you start developing antibodies to particular food proteins. And then people start feeling like they have food allergies and they do, they actually create particular food allergies. Now, one way to prevent leaky gut is to get the rest of the gut situation happy by ingesting the proper foods that we talked about before, ingesting fermented foods on a regular basis. The other is our old friend glutamine, again. There are some data and I should say it's a limited number of studies showing that ingesting glutamine anywhere from one to three, excuse me, teaspoons per day, can help alleviate leaky gut. Now, the mechanism for that still isn't clear whether or not it's adjusting pH or whether or not it's creating more favorable environment for the microbiota, but it is clear that supplementing with glutamine can, in some people enhance where I should say improve conditions of leaky gut, so that might be useful as well.

01:15:50 Gut Acidity: HCl (hydrochloric acid), Pepsin

And then the final thing about this, I want to talk about is we're talking about chemical sensing in the gut and how that impacts wellbeing is about gut acidity, and this I confess is a little bit controversial. Some people are on board, this other people are not. And so I'd love your feedback on this, if you, if you agree, please tell me if you disagree, please tell me, but please tell me why you disagree in particular, experience or data, although it's always better if you can point me towards peer reviewed studies. There is a practice that some people embrace. I'm not recommending people necessarily do this. And you

would definitely want to talk to your doctor, but where people have food allergies or they're having mood or auto-immune issues, and they treat this, some people recommend treating this through the ingestion of HCL, hydrochloric acid tablets. Now hydrochloric acid can burn you, right? Acids can burn you, they literally can melt away skin. You want to be very careful with acids of all kinds, truly, but hydrochloric acid is sold as in supplement form in capsule or pill form. And there is a practice of starting to ingest one or two hydrochloric acid tablets midway through a meal and then what people will generally do is examine to see whether or not that improves their symptoms of indigestion, how it relates to mood, how it relates to well-being, how it relates to their sensation of their gut viscera. By changing the acidity, you also changed the way that the gut communicates with the brain through the mechanisms we talked about before. And there are a growing number of people embracing these practices of taking HCL. It's often combined with other things, it's usually combined with an enzyme and that enzyme is pepsin. So most of these supplements come in the form betaine HCL pepsin and while they're not a cure-all, and certainly don't want to suggest that they're a cure-all, many people that have a hard time adjusting the pH of their gut and have a hard time adjusting the microbiota of their gut in the appropriate ways have benefited from taking these betaine HCL pepsin tablets or capsules during meals. And the general instruction is to start slow, to start with one or two, and then to find a level that you're comfortable with that doesn't create an excessive feeling of warmth in the stomach, it doesn't throw off your digestion. So it takes a little bit of experimentation, again, definitely talk to your healthcare provider before exploring this, but this has become a very common practice for people with auto-immune disorders and accessing the gut because it is accessible by taking things has also become way in which

01:18:30 Probiotics & Brain Fog

people with various mental conditions are trying to adjust their mood and adjust their wellbeing. Along these lines, I do want to mention that there are studies that show that people that supplement with a lot of probiotics or even prebiotics can sometimes experience brain fog. This isn't discussed a lot and the data are a little all over the place, but it is that we're thinking about. The goal here is not to create as many microbiota as possible, what you want is microbiota diversity. And I should mention this again in reference to the Sonnenberg study, which was what the high fiber diet does is it

increases certain microbiota, but it limits their diversity and what the fermented food diet does, or I should say the diet that includes regular ingestion of fermented foods a few servings a day is it increases microbiota diversity. Now, lack of microbiota diversity has a name in the medical profession. It's called dysbiosis and dysbiosis is bad. Dysbiosis is what you see when people are spending long periods of time on bedrest or when they've been chronically ill, and so here again, we're talking about creating a positive environment in the gut, either by adjusting acidity, maybe you explore the betaine HCL pepsin thing. I think if you have healthy digestion, if you feel like you have a good relationship to your gut, and it has a good relationship to you, sort of a silly phrase, because it is you and you are it, then I don't think there's any need to pursue this, but if you don't, that might be one avenue to pursue. However I think primary in all of this is the fermented food findings, and it's not just one study, it's many many findings that now bring us to a place where a huge center of massive data are pointing us in the direction of saying ingest fermented foods on a regular basis. I should also mention that conditions like sarcopenia, which is the loss of muscle tissue as we age, has been shown to be offset by improving the gut microbiota. So while today is about interoception, we're talking about sensing, we're also talking about subconscious sensing. What are we talking about, subconscious sensing, we're talking about subconscious sensing of the milieu of the body. When the milieu of the gut and the body is right, than the brain and the immune system function very well. And so this isn't something where you can sit back and say, oh, you know, I feel all those good microbiota in my gut, or, oh, no, those are bad microbiota. You can't do that unless you're going to take fecal samples and blood samples and analyze them in the, with the extreme exhaustive nature that the Sonnenberg and other labs do, you're not going to get that kind of information. I know there are companies out there that do this, and I don't want to knock on any of them, but I do want to emphasize that to do this right, to really analyze which cytokines you're making, which ones you're not, you really need to look at a huge number of them. And that requires large-scale proteomic and genomic and inflammatory markers screens. It's just not the kind of thing that most commercial enterprises can really provide to people in a way that they can interpret, rather, this is a case where you can simply go to the effector, to the thing that can actually move the needle in the right direction for you. It's very clear that's fermented foods and that's keeping

01:21:45 Nausea: Happens in Your Brain; Area Postrema

the stomach slightly more acid than one might think you would want to. So let's talk about barfing first. Barfing, AKA vomiting, is when the contents of your guts run in reverse, meaning when they go up from your stomach. Sometimes even up from the intestines, even though that sounds horrible, it sometimes happens up, out the esophagus and mouth and onto whatever surface happens to be in front of you. It's a terrible thing, nobody likes to do it, but it's a very interesting aspect of our biology because it reveals a beautiful and absolutely fundamental relationship between our chemistry and our brain. So your brain is actually locked behind a gate and that gate is not your skull. That gate is the so-called blood-brain barrier. So just like your gut has these epithelial tight junctions, the things I talked about before that provide a fence, so things can't get through and get through in leaky gut, your brain has tight junctions that are very tight. It's absolutely fundamental that only certain molecules get across the blood brain barrier and that others don't. And the reason for that is that most all 99.99999% of your neurons do not regenerate, I don't care what you've read, especially in the news recently about how psychedelics cause neurogenesis, because they don't, it's absolutely wrong. Psychedelics have effects on brain plasticity, but they have nothing to do with neurogenesis, at least no data to support it, but because you can't make new neurons, you also can't damage the ones you've got, or you shouldn't as much as possible. And that's why you have a blood brain barrier or a BBB. So the BBB as it's called prevents substances from getting to the brain, however, like any fence, it is not always uniform along its length. And there are little spots within that fence where chemicals can sneak across to the brain and through a beautiful design, I don't know anything about the design. As I always say, I wasn't consulted the design phase. I'm not talking about any kind of intelligent design or anything that is not the topic of this podcast. This is not a philosophy podcast, nor is it a religion podcast, it's a science podcast, but through a beautiful design of some sort, there are little holes in that fence. And they're little neurons that sit right behind those holes and those neurons sense what the chemistry of the blood is. So I'm guessing you probably didn't imagine that today's discussion about sensing the self would be sensing your own blood, but you do. There's a little area of your brain, that's little indeed, but is very important called area postrema P-O-S-T-R-E-M-A. And area postrema is an area of the brainstem that sits right next to another brain area called the chemo receptor trigger zone. And when the contents in

your bloodstream are of a particular kind, meaning when there are pathogens or it's too acidic, the neurons and area postrema the neurons in the chemo receptor trigger zone, the CTZ as it's called, trigger a bunch of motor reflexes in the abdominal wall that make you barf. Okay, the feeling that you need to throw up is triggered by these neurons in the brain stem. And those neurons in the brainstem are triggered by the presence of certain chemicals. And the reason why you don't have any blood brain barrier at that location is because post-trauma has to be there like a crossing guard, making sure that everything that's coming through the blood is okay, and if it even senses just the tiniest bit, that things are off, it's going to trigger that reflex. Now, the really interesting thing is that the neurons and area postrema respond to the chemistry of the blood, but they also will respond to our consciousness, to things that we think and things that we believe and even particular memories. This is why when certain people see vomit or see someone else vomit, or even somebody else heaving, as if they're going to vomit, they themselves feel as if they're going to vomit. I'm guessing they're probably even a few of you right now that feel like you might vomit. You might feel salivation in your throat, which is always a precursor to vomiting. Some people, the memory of, or the thought of something like blood or vomit or, use your imagination, can actually trigger the vomit reflex. And that's because these neurons in area are very sensitive to prior experience of interactions with negative things. So and actually, as I'm saying this, I feel my gut kind of cramping up again, I'm not, I don't vomit very easily, I'm not one of those, nor am I somebody who's never vomited. And here we are talking about my vomit history, but I think it's appropriate in this, in this context, the neurons of area, or they're basically to keep your whole system safe and thank goodness they are, because for instance, some people, unfortunately, they drink so much alcohol that they throw up. Have you ever wondered why that is? Well it's because alcohol fundamentally is a poison. I'm not saying for, you know, age appropriate folks that ingesting alcohol is bad. This isn't a judgment call, but alcohol itself at excessive levels in the bloodstream triggers post-trauma to cause vomiting. So this is an example, whereby memories, context, but also just the chemistry of our internal state is triggering behaviors that are very hardwired. They're very reflux driven. And why would it be that some people get more nauseous than others at a given level, well, they'll have to do with alcohol tolerance. Some people have what's called a, you know, we refer to as a stronger stomach or a stomach of steel. Other people they throw out very easily if they don't feel well, or if they ingest anything that's just a little bit off. From a purely adaptive standpoint, it's probably better to vomit

up things that aren't good for you rather than to have them pass through your system. Especially if those things are contained in lipids. For instance if you ingest something that's in liquid form because cells, literally every cell in your body is surrounded by a little thin layer of fatty tissue, we call the bilayer membrane, it's a little membrane. Fat can move through fat very easily. And so any bad stuff you ingest can get stuck in your system.

01:28:25 Protocol 9: Reducing Nausea: Ginger, Peppermint, CBD, etc.

So let's talk for a second about how to reduce nausea, because nausea is that salivation, that feeling that you're going to vomit, can be very beneficial in an, in an adaptive circumstance. Like you've ingested something bad, but some people experience nausea, for other reasons, there are good ways to regulate nausea and the ways they regulate nausea, very interesting. They actually adjust the activity of these neurons in area postrema or they change the chemistry of the blood directly. And many of you have heard this before, perhaps, but it turns out that there are good data, 11 research studies where the ones that I could find peer reviewed research studies with no bias, so independent studies showing that ginger can cause a notable reduction in nausea, how much ginger, one to three grams, what's one to three grams where you have to measure it out on a scale, unless you're taking it in pill or capsule form. It doesn't seem to matter if you take it in pill or capsule form, so this thing that you've heard before that ginger can reduce nausea, indeed is true. Peppermint, apparently can also do that. And some of you will not be surprised to learn that cannabis can reduce nausea, not surprise because cannabis, which has different legality in different places, and I understand that, so please take that into consideration. But cannabis, THC and, or it turns out CBD can reduce nausea, that's been shown in at least one study. And it probably does that, not by changing the chemistry of your blood, but by changing the threshold for firing of these neurons in area post-trauma. And there are conditions such as in chemotherapy and radiation therapy and others where people are feeling very nauseous, I'm not recommending people go use cannabis, unless they've decided with their selves and their family and their doctor that they should. But what's interesting is this thing about CBD and we'll do a whole episode on THC and CBD doesn't have, or isn't supposed to have these psychoactive properties that THC does. Although CBD can have a mild to major anxiolytic anxiety-reducing effect, but it does appear that the data

are what the data support. I should say, the anecdotal reports, which are that cannabis can reduce nausea.

01:30:40 Fever: Triggers and Control Knobs: OVLT

So to barf less, ginger, peppermint, and if appropriate and legal for you, possibly cannabis. Now let's talk about fever. In previous episodes, and in future episodes, we deal with thermal regulation, which is the body's ability to regulate its temperature. Talk about cold and heat and saunas and ice baths and physical performance. We're not going to deal with all that right now, but I promise we will going forward. Today, I only want to talk about fever because fever directly relates to interoception. What do I mean by that? Well, a fever is simply an increase in body temperature, that increase in body temperature is triggered by neurons in the brain. And those neurons in the brain are triggered by the presence of particular things in the bloodstream. What sorts of things? Well, toxins, bacteria, viruses, when something bad gets in our system, the body doesn't know it's bad, it just knows it's foreign, and it hasn't seen it before. Or that it's in the wrong compartment of the body. So earlier we were talking about proteins that leak out of the gut and get elsewhere, you know, you don't want a piece of steak sitting in your bicep. That would be bad, you would actually develop antibodies, you would have a horrible infection. But your body has this intelligence, and that intelligence is to know, Hmm, these proteins are normally not seen in this region and then your body or the cells there, I should say, we'll release something that then will travel to the brain and will trigger an increase in body temperature so that your body cooks the bad thing or the cause of the bad thing. It's really a beautiful adaptive mechanism. We always think fever is so terrible, but fever is there to cook the bad thing that's inside you, or that has left the correct compartment inside you and is in the wrong compartment inside you. So what's beautiful about the fever mechanism is that it looks a lot like the barfing mechanism. Basically you have a set of neurons that sit near the ventricles, remember the ventrals is hole in the tube, that is you, the tube that is, you are a tube, a series of tubes. And your brain has a hole down the middle. And it extends down to the bottom of your spinal cord, at the front, it's called the ventricles, they start with what are called the lateral ventricles and the excuse me, starts with the third and the lateral ventricles, and then it goes to the fourth ventricle and then to what's called the central canal. But basically is just a big space in the middle of your nervous system in the middle of your brain. And you have

one ventricle that I already mentioned called the third ventricle. And it's shaped kind of like a thin oval up upright, if you're listening to this, just think an I, the shape of an I, but it's kind of rotated 90 degrees. So it's up and down as opposed to across. And along that third ventricle, there's there a little neurons that can sense what's in the cerebral spinal fluid that fills the ventricle. So in other words, you have neurons that are sensing the chemistry of your cerebral spinal fluid, and that have access therefore to the chemistry of your body. Because that cerebral spinal fluid is going up and down the brain and spinal cord. But into that cerebral spinal fluid are signals about the various chemicals within the body. So this is not a mechanical system. This is a chemical system. Remember we're talking about mechanical information and chemical information accessing the brain. So if you have something bad in your system, you've ingested a, you breathe in a virus or you inhaled some bacteria, or you got a cut on your leg and some bacteria are growing there. Of course, locally, there will be effects, little things called the mast cell. This M-A-S-T little packets of histamine literally will go there and explode [poofs] and cause inflammation, which is actually a good inflammation. And we'll release little things called macrophages to gobble up the infection. The other day, it was in Texas, it was some mean little mosquitoes in Texas, and a lot of them, and I would stand outside and I'd get bitten, I didn't feel a thing, but then later that night, they started swelling up and itching and then I'd itch them, and then they'd swell even more. That was because of the release of mass cells, of histamines inside those mass cells that would literally causing inflammation of the tissue. It wasn't the poison from the mosquito itself. It was the immune response to those. Well, you also have this systemic or body-wide attempt to kill stuff, and that's the fever. So the neurons that these ventricles with cerebral spinal fluid go by a particular name, they're called circumventricular organs, meaning near circum, ventricular near the ventricles. And you have these organs and there are a set of neurons, has a really cool name called the OVLT. I don't know why I like that, but I just like it, it's the organum vasculosum of the lateral terminalis organum vasculosum of the lateral terminalis, OVLT are the neurons that respond to toxins and bad stuff in your bloodstream, however minor or major. And they release things like ILK-1, which are inflammatory cytokines inflammatory in this case is good, you want inflammation at the site of an infection. It's a good thing. It's going to help with healing. And it's going to change the conditions in your body, what's going to happen is when those OVLT neurons are activated, because you have something bad in your body or something bad is happening in your body, they communicate with an area of the brain called the

preoptic area of your hypothalamus and the preoptic area cranks up your temperature and tries to cook that bad thing. Now it's worth talking about fever for a moment and talking about thermal regulation, because I think this actually could save some lives. So if you are overheated to a point where, you know, you're getting up past 102 or 103, it's going to vary depending on person to person and certainly age, you know, kids, some people think can tolerate higher levels of fever than adults, but look, you always want to be cautious about heating up the brain too much, because once those neurons are gone, they do not come back and neurons do not do well in very high temperatures. Once your body temperature starts getting up to 102, 103, certainly 104, you are starting to enter serious danger zone. This can happen through exercise in hot environments or an inability to escape heat because you don't have covering or adequate ventilation or cooling. It can also be because of excessive fever,

01:37:00 Protocol 10: Cooling the Blood Properly

for whatever reason. A lot of people think the way to deal with this is to put a cool compress on the back of the neck or to cool the torso. In discussing this with my colleague, Craig Heller who's at Stanford School of Medicine, and he's on the undergraduate side of the campus as well, runs a biology lab. He's a world expert in thermal regulation. It's very clear that that's the wrong response to try and cool off the body. If you put a cold towel or you put an ice pack on the back of the neck, what you effectively do is cool the blood that's going to the brain. And if you do that, then your brain will react by turning up the crank in so to speak on the neurons in the pre optic area, and will heat you up further and can cook your brain and organs further. So what you want to do is, as I've talked about before, you want to cool the bottoms of the feet, the palms of the hands and the upper part of the face. And I'm not going to go into all the details as to why you want to do that right now, but those are the locations you want to cool. Now you can also cool the rest of the body, but it's not okay to just stay under the covers and just cool, you know, the neck or something like that. You really want to try and create a systemic or whole body cooling, if the goal is to bring fever down, but in many cases, fever is adaptive. And so taking a non-steroid anti-inflammatory drugs like Advil and Tylenol sometimes can be good, if that's recommended, but other times, because it reduces your fever, it's allowing that pathogen, that pyrogen, it's sometimes called, a pyrogen is a substance that causes fever, think pyro, think fire, think

pyromaniacs, think pyro, those pyrogens can survive at moderate to low temperatures, and they can't survive at high temperatures. So the fever is an adaptive mechanism and the OVLT,

01:38:53 Sensing Feelings, Vagus Nerve, Stress

and the sensing of your chemistry is how the OVLT, organum vasculosum of the lateral terminalis does that. So we've talked about sensing lung volume, speed of our heartbeat, we talked about sensing the gut volume, the intestinal volume, or the absence of volume. We talked about chemistry of the gut and the gut microbiota and auto immune functions. And we've now talked about vomiting, and we've talked about fever, lots of aspects of sensing our internal self. Now I want to turn our attention to interoception as it relates to feelings, the way that interoception is most commonly described. And I want to highlight a term that many of you have probably heard, which is the vagus nerve. We talked about vagus a little bit earlier, but the vagus nerve, this vagabonding wandering nerve is involved in everything I've talked about up until now. And the reason I saved it till now, rather than mentioning all along is to highlight a specific point, which is that whenever we hear about the vagus in popular culture, it's like the vagus calms you down, you want to stimulate the vagus by rubbing in front of the ear, and it's a parasympathetic nerve, and it will calm you down, he'll mellow you out. Actually, most of the time, the vagus is stimulatory. When you ingest foods with amino acids, sugars, or fatty acids, the vagus nerve gets activated and triggers the release of dopamine, it makes you more alert and go seek more of those foods or what led to those conditions. When you feel nauseous it's rarely calming, when you feel like you have a fever, it's rarely calming. So you're starting to get the picture that even though the vagus nerve is in the parasympathetic branch of the autonomic nervous system. And if that doesn't mean anything to you, because you're not in aficionado, don't worry about it. But it's not a calming system, it's a communication system, and it's a motor system. It communicates brain to body and body to brain, and it changes the function of different organs, now, one thing that's important to highlight is that stress itself will alter the chemistry of your gut because of the ways that it down the vagus nerve and quiets the neurons that communicate from gut to brain. I want to say that again, stress will disrupt your gut and make you feel not good, poor digestion, and just lousy, because of the way that it shuts down the vagus nerve and the neurons of your gut. So what stress does is it

blocks the communication between gut and brain, it doesn't mess up your gut. It just doesn't let your gut get the signals up to your brain, and it also then throws off the chemistry. And then there's a whole cascade of effects. If you want to learn more about stress, I did a whole episode called "Master Stress," or I think maybe it was called "Conquer Stress" and it was "Master Stress," either one. The whole point of that episode is to give you tools and practices to deal with short term, acute stress, moderate term stress, and long-term chronic stress through behavioral mechanisms,

01:41:50 Mental Emotions Reflect Bodily Conditions

nutrition, supplementation, and many other things as well. It's chockablock full of protocols and tools for stress. The vagus nerve, however, is responsible for emotion and the way it does that is to pool, to aggregate the conditions of your gut, the conditions of your heart and the conditions of your breathing, which includes your diaphragm and lungs and takes that kind of as a collection of information and sends it to the brain and controls what we call your emotions. Now that might seem obvious to some people, but to other people that might seem totally crazy. You thought your emotions were because the market was down and you had invested, or because something that you thought was going to happen is not going to happen, or because you thought that school was open and then it's not, or maybe thought it wasn't, and it is whatever it is that bothers you, you think of generally as a purely cognitive event. But the brain doesn't really know what to do with that information. It doesn't act directly on that information to create moods. Moods are created through the heart's response to reading that headline, to the change in your breathing, that's caused by someone that you love telling you that actually they're not interested in spending time with you anymore, or that you screwed up or that they're interested in spending a lot of time with you and you like that, right? Emotions can be good or bad or neutral. So this thing that we call interoception, the sense of self I've been building up from very fundamental layers, gut chemistry, spleens, immune systems, auto-immune and you might've been thinking, wait, I thought this was going to be about a sense of self, a noticing or a feeling. And indeed all of those things are plugging in like a series of ingredients in a recipe that gives rise to your mood and how you feel, and that mood and how you feel is shown in one location in your body that other people can see. And that's in your facial expressions. And indeed there are now beautiful data showing that your face, including the size of your pupils, the tonality of

your face, how flushed you are, or how pale you are, even the degree to which you're frowning or smiling relative to other periods of time, that is all an aggregate of, or a reflection rather of your gut, your heart and your breathing and the chemistry of your body. And so this is why I sort of backed into this conversation about interoception I kind of Trojan horse this on you on purpose which is that when we talk about the vagus and you hear, oh, you know, you can get vagal tone by breathing or rubbing on the front of the or short that's probably true, but another fundamental layer is the acidity of your gut, how fast your breathing are you inhale-emphasized, or exhale-emphasized breathing. When we are relaxed our pupils tend to constrict. When we are very alert, our pupils tend to be dilated, whether or not that alertness has to do with being happy or being sad.

01:45:00 Sensing Other People's Emotions via the Body

And what's remarkable, and this is where interoception really takes a leap into the incredible is that there are beautiful studies that show that for instance, when we know somebody pretty well and they are going through some sort of experience of any kind, our heart rate actually starts to mimic their heart rate. Our breathing starts to mimic their breathing, even if we aren't conscious of their breathing. It's not like we see their chest heaving, and we think, oh my goodness, and then we breathe that way. There's a mirroring and no it's not carried out through mirror neurons. Mirror neurons are more of a myth and a reality, sorry to burst people's bubbles. But that bubble around mirror neurons is definitely made of myths and a topic for another time, but we start to mirror. Somehow human beings are able to register the internal state of other beings, and I think probably for animals too, but certainly for other humans, even at a distance. And these studies are many now, and they're really wonderful studies.

01:46:00 Protocol 11: Increasing Interoception, Sensing Heartbeat

And so your sense of your internal landscape is linked to others. Now you can enhance this interoceptive capacity for how you feel and how others feel, in other words, you can start getting a better readout of your internal state by doing a simple exercise, what is really a tool. And that is to learn to sense your heartbeats. So some people are very good at this, other people are not, some people can do this more easily when they have all their air exhaled and some people can do it better when they are holding a breath

hold. But one thing that's kind of cool about this whole interoceptive capacity is that you can enhance it very quickly. You can learn or teach yourself to have heightened levels of interoception in a way that you can't really just give yourself heightened levels of vision by snapping your fingers, in one of one tool or exercise, there are things you can do to improve vision. That's the topic of a previous episode. I encourage you to look it up. There are things you can do to improve your hearing and your taste and your smell, we talked about all those, but with interoception you can get very good at this very fast. And I think this is one of the reasons why meditation is powerful. Think there are a lot of reasons why meditation is powerful, but one of the reasons is when you stop taking in exteroceptive information from the outside world, by closing your eyes and focusing inward, as they say, you start paying attention to your breathing cadence, you start directing your mind's attention to your heart rate, and if you can start to perceive your heart beating. You actually are very quickly strengthen the vagal connections between the body and the brain. And so there's no real practice here. There's no breathe this way or do this thing except to direct your awareness toward your heartbeat. And some people can get very good at this very fast. Most people find that just by doing this for a minute or so, every once in a while, they start to tap into this sixth sense. They start to notice when they don't feel quite right about something or somebody or some situation, or they start to notice when they feel quite right about somebody or something or some situation. So this interoceptive awareness can be tuned up. It used to be called vagal tone, but I think that term doesn't take into account all the other things that are going on with the vagus. So I don't really like that term. It's more of an interoceptive awareness. And again, there are many studies now showing that for sake of bettering one's mood overall, for sake of moving through a challenging phase in life, for sake of just enhancing one's experience of life overall, whether or not it's the taste of foods, interactions with other people, enjoyment, focus, pleasure, tuning up one's interoceptive awareness is both easy again by just taking a minute or two and trying to count heartbeats. And then this works best, of course, if you have some independent readout of heartbeats and you can compare, you can see how accurate you are, but even if you don't use a device or have a device to do that, without taking your pulse, using your thumb on your wrist or something, or your fingers on your neck, as you typically would for taking your pulse, trying to sit still for a minute or two every once in a while, maybe once a week, maybe twice a week, maybe while you're meditating, maybe while breathwork, maybe during the breath holds of breathwork, you don't really have to do this in any kind of extended

way, you can very quickly increase your interoceptive tone. And that has a huge and outsized effect on the brain, body relationship and your brain's ability to tap into both the subconscious and the conscious aspects of this chemical and mechanical signaling that's happening all the time. And it can have real and out-sized positive effects on your ability to engage with other people and your ability to focus at work and your ability to notice, ah, I'm finding myself kind of feeling like I'm losing focus, but really it was my heart rate was just increasing. Maybe I just exhale a little bit and bring my heart rate down. So whatever effectually tried to do today is to give you a window into this incredible relationship between your viscera and your brain and your brain and your viscera, all these organs of your body, and what I hope is that you'll appreciate that it's a system, that you aren't just a system of tubes. I said that in a sort of in jest, I mean, you have a lot of tubes and you are a system of tubes, but that system of tubes is linked through the nervous system, and those links work in very specific ways. So whether or not you remember about pesos and all the GLPRs and all that stuff, it doesn't really matter. What I encourage you to do is start sort of pushing and

01:50:40 Conclusions & Resources

pulling on the various leavers within this beautiful system that we call the interoceptive system, this sense of self. If you're learning from this podcast and or if you're enjoying it, please subscribe to our YouTube channel. That really helps us. Also on the YouTube channel, please leave us comments and feedback, including feedback of topics you'd like to see in future episodes or guests, you'd like to see on future episodes. We do read all the comments. In addition, please subscribe on Apple and Spotify and follow us on Instagram @hubermanlab. If you want to leave us a five-star review on Apple, you also have the opportunity to leave us a five-star review. You can also leave us comments and feedback on Apple. During the course of today's episode, and on previous episodes, I mentioned supplements. I realized supplements aren't for everybody, but for those of you that are interested in supplements, it is important that the supplements that you take have a high level of stringency with respect to the amounts of the contents that are listed on the bottle matching what's actually in the bottle, in the capsules and tablets, and that the quality of those ingredients be extremely high. For that reason we partnered with Thorne, that's T-H-O-R-N-E because Thorne supplements have the highest levels of stringency for both the content and the amount of content in those bottles and

supplements. If you want to try Thorne supplements, and you want to see the supplements that I take, you can go to thorne.com/U/Huberman. And you can see all the supplements that I take. You can get 20% off any of those. And if you enter the Thorne site through that portal, you can get 20% off any of the supplements that Thorne makes. In addition we have a Patreon account, it's patreon.com/andrewhuberman. There you can support the podcast at any level that you like. Please also visit us at hubermanlab.com and sign up for our free newsletter, our newsletter starts in August 2021, and you'll be receiving protocols and excerpts from podcasts, some condensed information that we think will really be a value to you, it's totally zero cost. Again, just go to hubermanlab.com and sign up for what we call our Neural Network Newsletter. And most of all, thank you for your time and attention. And thank you for your interest in science.