Welcome to the Uberman Lab podcast where we discuss science and science-based tools for everyday life. I'm Andrew Uberman and I'm a professor of neurobiology and ophthalmology at Stanford School of Medicine. 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. Today we're going to talk about chemical sensing. We're going to talk about the sense of smell, our ability to detect odors in our environment. We're also going to talk about taste, our ability to detect chemicals and make sense of chemicals that are put in our mouth and into our digestive tract. And we are going to talk about chemicals that are made by other human beings that powerfully modulate the way that we feel, our hormones and our health. Our last category are sometimes called pheromones. However, whether or not pheromones exist in humans is rather controversial. There actually hasn't been a clear example of a true human pheromonal effect, but what is absolutely clear, what is undeniable, is that there are chemicals that human beings make and release in things like tears onto our skin and sweat and even breath that powerfully modulate or control. The biology of other individuals. In fact, right now, even if you're completely alone, your chemical environment internally is being controlled by external chemicals. Your nervous system and your hormones and your metabolism are being modified by things in your environment. So we're going to talk about those. It's an absolutely fascinating aspect to our biology. It's one of our most primordial meaning primitive aspects of our biology, but it's still very active in all of us today. This episode, believe it or not, will have a lot of tools, a lot of protocols. Even though I'm guessing most of you can probably smell your environment just fine, that you know what you like to eat and what tastes good and what doesn't taste good to you. Today's episode is going to talk about tools that will allow you to actually leverage these chemical sensing mechanisms, including how you smell, not how you smell in the qualitative sense, but how you smell in the verb sense, the action of sniffing and smelling to enhance your sense of smell and to enhance your sense of taste as well. Believe it or not, to enhance your cognition, your ability to learn and remember things. Everything we're going to talk about, as always, is grounded in quality peer reviewed studies from some excellent laboratories. I will provide some resources along the way. So that means tools and protocols and also basic information. You're going to learn a ton of neuroscience and a lot of biology in general. And I think what you'll come to realize by the end is that while we are clearly different from the other animals, there are aspects to our biology that are very similar to that of other animals in very interesting ways. Before we dive into chemical sensing, I want to just briefly touch on a few things from the vision episode. One is a summary of a protocol. So I covered 13 protocols last episode. If you haven't seen that episode, check it out. Those protocols will allow you to be more alert and to see better over time. If you follow them, all of them are zero cost. You can find any and all of them at HubermanLab.com. There's a link to those videos and tools and protocols. Everything is timestamped. The two protocols that I just want to remind everybody of are the protocol of near-far viewing that all of us, regardless of age, should probably spend about five minutes, three times a week, doing some near-far viewing exercises. That would be bringing a pen or pencil up close to the point where you're about to cross your eyes, but you don't cross your eyes. And then out at some distance and then look beyond that pen or other object that you're using, off as far as you can into the distance. It would be great if you could do this on a balcony or deck and then look way off in the distance and then bring it back in. This is going to exercise that accommodation reflex. The change in the shape of the lens can help offset a number of things, including myopia, near-sidedness. The other one is this incredible study that showed that two hours a day outside, even if you're doing other things while you're outside can help offset myopia, near-sidedness. So try and get outside. It's really the sunlight and the blue light, right? Everyone's been demonizing blue light out there, but blue light is great. Provided it's not super, super bright and really close to your eyes. Blue light is terrific. If it comes from sunlight, two hours a day outside is going to help offset myopia, near-sidedness. That's a lot of time. I think most of us are not getting that time, but since you can do other things like gardening or reading or walking or running, if you can get that two hours outside, your visual system and your brain will benefit. I also would like to make one brief correction to something that I said incorrectly in the previous episode. At the end of the episode, I talked about luteen and how luteen may help offset some moderate to severe age-related macular degeneration, as well as how some people are supplementing with luteen, even though they don't have age-related macular degeneration, with the idea of mind that it might help offset some vision loss as they get older. I said luteen and luteen was the correct thing to say, but once or twice, when I started speaking fast, I said lucine and not luteen. I want to emphasize that lucine and amino acid, very interesting, important for muscle building covered in previous episodes, but luteen, LUT, EIN, is the molecule in compound that I was referring to in terms of supplementing for sake of vision. I apologize, please forgive me, I misspoke, a couple of you caught that right away in listening to the episode after it went up, I realized that I had misspoken. LUT, LUT, LUT, for muscles and muscle growth and strength, etc. Before we dive into the content of today's episode, I want to just briefly touch on color vision. Many of you asked questions about color vision and color perception, and indeed color perception is a fascinating aspect of the human visual system. It's one of the things that makes us unique. There are certainly other animals out there that can detect all the colors of the rainbow. Some can even detect into the infrared and to the far red that we can't see, but nonetheless, human color vision provided that somebody isn't colorblind is really remarkable. If you're interested in color vision or you want to answer questions about art or about, for instance, why that dress that showed up online a few years ago looks blue to you and yellow to somebody else, all the answers to that are in this terrific book, which is what is color? 15 questions and answers on the science of color. I'm not right this book, I wish I had. The book is by Ariel and Joan X-Dut, that's ECKSTUT, so it's what is color? 50 questions and answers on the science of color. It's an absolutely fabulous book. I have no business relationship to them. I did help them get in contact with some color vision scientists when they reached out to me. You can know that all the information in the book was vetted by excellent color vision scientists. It's a really wonderful and beautiful book. The illustrations are beautiful. If you're somebody who's interested in design or art or you're just curious about the science of color, it's a terrific book. I highly recommend it. If you just look up it up online, there are a variety of places that will allow you to access the book. Let's talk about sensing chemicals and how chemicals control us. In our environment, there are a lot of different physical stimuli. There is light photons, which are light energy, and those land on your retinas, and your retinas tell your brain about them, and your brain creates this thing we call vision. There are sound waves, literally particles moving through the air and reverberations that create what we call sound and hearing. And of course, there are mechanical stimuli, pressure, light touch, scratch, tickle, etc. that lands on our skin or the blowing of a breeze or that deflects the hairs on our skin. We can sense mechanical touch, mechanical sensation, and there are chemicals. There are things floating around in the environment, which we call volatile chemicals. It just means that they're floating around out there. So when you actually smell something, like let's say you smell a wonderfully smelling rose or cake, yes, you're inhaling the particles into your nose. There are literally little particles of those chemicals are going up into your nose and being detected by your brain. Also, if you smell something, putrid, disgusting or awful use your imagination. Those particles are going up into your nose and being detected by neurons that are part of your brain. Other ways of getting chemicals into our system is by putting them in our mouth, by literally taking foods and chewing them or sucking on them and breaking them down into their component parts. And that's one way that we sense chemicals with this thing, our tongue. And there are chemicals that can enter through other mucosal linings and other kind of just think damp sticky linings of your body. And the main ones would be the eyes. So you've got your nose, your eyes, and your mouth. But mainly when we have chemicals coming into our system, it's through our nose or through our mouth. Although sometimes through our skin, certain things can go transdermal, not many, and through our eyes. So these chemicals, we sometimes bring into our body, into our biology, through deliberate action. We select the food, we chew that food, and we do it intentionally. Sometimes they're coming into our body through non deliberate action. We enter an environment and they're smoke and we smell the smoke. And as a consequence, we take action. Sometimes we are forced to eat something because somebody tells us we should eat it or we do it to be polite. So there are all these ways that chemicals can make it into our body. Sometimes, however, other people are actively making chemicals with their body. Typically, this would be with their breath, with their tears, or possibly, I want to underscore possibly, by making what are called pheromones, molecules that they release into the environment, typically through the breath, that enter our system through our nose, our eyes, our mouth, that fundamentally change our biology. I will explain how smell and taste and these pheromone effects work. But I'll just give an example, which is a very salient and interesting one that was published about 10 years ago in the Journal Science. Science magazine is one of the three what we call apex journals. There are a lot of journals out there, but for those of you that want to know, Science Magazine Nature Magazine and Cell are considered the three top kind of apex journals. They are the most stringent in terms of getting papers accepted there, even reviewed there. They have about a 95% rejection rate at the front gate, meaning they don't even review 95% of what gets sent to them. Of the things that they do decide to review, then get sent out a very small percentage of those get published. It's very stringent. This paper came out in science showing that humans, men in particular in this study, have a strong biological response and hormonal response to the tears of women. What they did is they had women, and in this case it was only women for whatever reason, cry and they collected their tears. Then those tears were smelled by male subjects, or male subjects got what was essentially the control, which was the salient. Men that smelled these tears that were evoked by sadness had a reduction in their testosterone levels that was significant. They also had a reduction in brain areas that were associated with sexual arousal. Now, before you run off with your interpretations about what this means and criticize the study for any variety of reasons, let's just take a step back. I will criticize the study for a variety of reasons too. One is that they only used female tears and male subjects. It would have been nice for them to also use female tears and female subjects, smelling those, male tears and male subjects smelling those, male tears and female subjects smelling those and so on. They didn't do that. They did have a large number of subjects, so that's good. That adds power to the study. They did have to collect these tears by having the women watch a, what was essentially a sad scene from a movie. They actually recruited subjects that had a high propensity for crying at sad movies, which was not all women. It turned out that the people that they recruited for the study were people who said, yes, I tend to cry when I see sad things in movies. What they're really trying to do is just get tears that were authentically cried in response to sadness as opposed to putting some irritant in the eye and collecting tears that were evoked by something else, like just having the eyes irritated. Nonetheless, what this study illustrates is that there are chemicals in tears that are evoking or changing the biology of other individuals. Most of us don't think about sniffing or smelling other people's tears, but you can't imagine how in close couples or in family members or even close friendships, etc. that we are often in close proximity to other people's tears. I didn't select this study as an example because I want to focus on the effects of tears on hormones per se, although I do find the results really interesting. I chose it because I wanted to just emphasize or underscore the fact that chemicals that are made by other individuals are powerfully modulating our internal state. That's something that most of us don't appreciate. I think most of us can appreciate the fact that if we smell something putrid, we tend to retract or if we smell something delicious, we tend to lean into it. But there are all these ways in which chemicals are affecting our biology and interpersonal communication using chemicals is not something that we hear that often about, but it's super interesting. Let's talk about smell and what smell is and how it works. I'm going to make this very basic, but I am going to touch on some of the core elements of the neurobiology. Here's how smell works. Smell starts with sniffing. That may come as no surprise, but no volatile chemicals can enter our nose unless we inhale them. If our nose is occluded or if we're actively exhaling, it's much more difficult for smells to enter our nose, which is why people cover their nose when something smells bad. The way that these volatile odors come into the nose is interesting. The nose has a mucosolining mucus that is designed to trap things, to actually bring things in and get stuck there. At the base of your brain, so you could actually imagine this or if you wanted, you could touch the roof of your mouth and write about it. Now, about two centimeters is your olfactory bulb. The olfactory bulb is a collection of neurons and those neurons actually extend out of the skull, out of your skull, into your nose, into the mucosolining. What this means in a literal sense is that you have neurons that extend their little dendrites and acts only like things or little processes as we call them, out into the mucos, and they respond to different odorant compounds. Now, the olfactory neurons also send a branch deeper into the brain and they split off into three different paths. So, one path is for what we call innate odor responses. So, you have some hard-wired aspects to the way that you smell the world, that were there from the day you were born and that will be there until the day you die. These are the pathways and the neurons that respond to things like smoke, which as you can imagine, there's a highly adaptive function to being able to detect burning things, because burning things generally means lack of safety. Or impending threat of some kind. It calls for action and indeed these neurons project to a central area of the brain called the amygdala, which is often discussed in terms of fear, but it's really a fear and threat detection. So, some compounds, some chemicals in your environment, when you smell them, unless you're trained to overcome them because you're a firefighter, you will naturally have a heightened level of alertness, you will sense threat. And if you're in sleep even, it will wake you up. So, that's a good thing. It's kind of an emergency system. You also have neurons in your nose that respond to odorants or combinations of odorants that evoke a sense of desire and what we call, repetitive behaviors, approach behaviors that make you want to move toward something. So, when you smell a delicious cookie or some dish that's really savory that you really like or a wonderful orange, and you say, mmm, or it feels delicious or it smells delicious, that's because of these innate pathways, these pathways that require no learning whatsoever. Now, some of the pathways from the nose, these olfactory neurons into the brain, are involved in learned associations with odors. Many people have this experience that they can remember the smell of their grandmother's home or their grandmother's hands even, or the smell of particular items baking or on the stove in a particular environment. Typically, these memories tend to be of a kind of nurturing sort of feeling safe and protected. But one of the reasons why olfaction, smell, is so closely tied to memory, is because olfaction is the most ancient sense that we have, or I should say chemical sensing is among the most primitive and ancient senses that we have, probably almost certainly evolved before vision and before hearing. But when we come into the world, because we're still learning about the statistics of life, about who's friendly and who's not friendly and where's a fun place to be and where's a boring place to be, that all takes a long time to learn. The olfactory system seems to imprint, seems to lay down memories very early and to create these very powerful associations. And if you think about it long enough, and hard enough, many of you can probably realize that there are certain smells that evoke a memory of a particular place or person or context. And that's because you also have pathways out of the nose that are not for innate behaviors like cringing or repulsion or gagging or for that repetitive sensation, but that just remind you of a place or a thing or a context. Could be flowers in spring, could be grandmother's home and cookies. This is a very common occurrence and it's a very common occurrence because this generally exists in all of us. So we have pathway for innate responses and a pathway for learned responses. And then we have this other pathway and in humans, it's a little bit controversial as to whether or not it sits truly separate from the standard olfactory system or whether or not it's own system embedded in there, but that they call the accessory olfactory pathway. Accessory olfactory pathway is what in other animals is responsible for true pheromone effects. We will talk about true pheromone effects, but for example in rodents and in some primates, including mandrels, if you ever see a mandrel, they have these like beak noses, things you may have seen them at the zoo, look them up if you haven't seen them already, M-A-N-D-R-I-L-S. mandrels, there are strong pheromone effects. Some of those include things like if you take a pregnant female rodent or mandrel, you take away the father that created those fetuses or fetus, and you introduce the scent of the urine or the fur of a novel male. She will spontaneously abort or miscarry those fetuses. It's a very powerful effect. In humans, it's still controversial whether or not anything like that can happen, but it's a very powerful pheromone effect in other animals. Another example of a pheromone effect is called the Vandenberg effect, named after the person who discovered this effect, where you take a female of a given species that has not entered puberty, you expose her to this scent or the urine from a sexually competent, meaning post-puberadol male, and she spontaneously goes into puberty earlier. Something about the scent triggers something through this accessory olfactory system. This is a true pheromone effect and creates ovulation, right? And menstruation, or in rodents, it's an ester cycle, not a menstrual cycle. So this is not to say that the exact same things happen in humans. In humans, as I mentioned earlier, there are chemical sensing between individuals that may be independent of the nose, and we will talk about those. But those are basically the three paths by which smells, odors, impact us. So I want to talk about the act of smelling. And if you are not somebody who is very interested in smell, but you are somebody who is interested in making your brain work better, learning faster, remembering more things, this next little segment is for you, because it turns out that how you smell, meaning the act of smelling, not how good or bad you smell, but you are not the same. So I want to talk about the act of smelling, and how you are getting more things, this next little segment is for you, because it turns out that how you smell, meaning the act of smelling, not how good or bad you smell, but the act of smelling, sniffing, and inhalation, powerfully impacts how your brain functions and what you can learn and what you can't learn. Breathing generally consists of two actions, inhaling and exhaling, and we have the option, of course, to do that through our nose or our mouth. I've talked on previous episodes about the fact that there are great advantages to being a nasal breather, and there are great disadvantages to being a mouth breather. There are excellent books and data on this. There's the recent book, Breath by James Nestor, which is an excellent book that describes some of the positive effects of nasal breathing, as well as other breathing practices. There's also the book, JAWS by my colleagues Paul Erlich and Sandra Conn, with a forward by Jared Diamond, and an introduction by Robert Sapolsky from Stanford. So that's a book, Chocoblock, with heavy hitter authors, that describes how being a nasal breather is beneficial for jaw structure, for immune system function, et cetera. Breathing in through your nose, sniffing actually has positive effects on the way that you can acquire and remember information. Nome Sobel's group, originally at UC Berkeley, and then at the Weitzmann Institute, has published a number of papers that I'd like to discuss today. One of them, Human Non-Oll Factory Cognition of FaZe Locked with Inhalation, this was published in Nature Human Behavior, an excellent journal, showed that the act of inhaling has a couple of interesting and powerful consequences. First of all, as we inhale, the brain increases in arousal, our level of alertness and attention increases when we inhale, as compared to when we exhale. Now of course, with every inhale, there's an exhale. You could probably double up on your inhales if you're doing size or some of the physiological size I've talked about these before, it's a double inhale followed by an exhale, something like that. Or if you're speaking, you're going to change your cadence and ratio of inhales and exhales. But typically, we inhale, then we exhale. As we inhale, what this paper shows is that the level of alertness goes up in the brain. And this makes sense because as the most primitive and primordial sense by which we interact with our environment and bring chemicals into our system and detect our environment, inhaling is a cue for the rest of the brain to essentially to pay attention to what's happening, not just to the odors. And as the name of this paper suggests, human non-olfactory cognition, FaZe Locked with Inhalation, what that means is that the act of inhaling itself wakes up the brain. It's not about what you're perceiving or what you're smelling. And indeed sniffing as an action, inhaling as an action has a powerful effect on your ability to be alert, your ability to attend, to focus, and your ability to remember information. When we exhale, the brain goes through a subtle, but nonetheless significant dip in level of arousal and ability to learn. So what does this mean? How should you use this knowledge? Well, you could imagine, and I think this would be beneficial for most people to focus on nasal breathing while doing any kind of focused work that doesn't require that you speak or eat or ingest something. There is a separate paper published in the journal neuroscience that show that indeed if subjects, human subjects are restricted to breathing through their nose, they learn better than if they have the option of breathing through their mouth or a combination of their nose and mouth. These are significant effects in humans using modern techniques from excellent groups. So sniffing itself is a powerful modulator of our cognition and our ability to learn. You can imagine all sorts of ways that you might apply that as a tool. And I suggest that you play with it a bit that if you're having a hard time staying awake and alert, you're having a hard time remembering information, you feel like you have a kind of attention deficit, nonclinical, of course, nasal breathing ought to help. Extending or making your inhales more intense ought to help. Now this isn't really about chemical sensing per se, but here's where it gets interesting and exciting. If you are somebody who doesn't have a very good sense of smell, or you're somebody who simply wants to get better at smelling and tasting things, you can actually practice sniffing. I know that sounds ridiculous, but it turns out that simply sniffing nothing. So doing something like this. I guess the microphone sort of has a smell. I guess a pen doesn't have a smell. It turns out that doing a series of inhales and of course each one is followed by an exhale, 10 or 15 times. And then smelling an object like an orange or another item of food or even the skin of somebody else will lead to an increase in your ability to perceive those odors. Now there are probably two reasons for that. One reason is that the brain systems of detecting things are waking up as a mere consequence of inhaling. So this is sort of the olfactory equivalent of opening your eyes wider in order to see more or less. Last episode I talked about how opening your eyes wider actually increases your level of alertness. It's not just that your level of alertness causes your eyes to be open wider. Opening your eyes wider can actually increase your level of alertness. Well, it turns out that breathing more deeply through the nose wakes up your brain and it creates a heightened sensitivity of the neurons that relate to smell. And there's a close crossover. I'm sure you know this between smell and taste. If any of you have ever had a cold or you've had for whatever reason you've lost your sense of smell, you become what they call a nosmic. Your sense of taste suffers also. We'll talk a little bit more about what that is in a few minutes. But as a first protocol, I'd really like all of you to consider becoming nasal breathers while you're trying to learn while you're trying to listen while you're trying to wake up your brain in any way and learn and retain information. This is a powerful tool. Now there are other ways to wake up your brain more as well. For instance, the use of smelling salts. I'm not recommending that you do this necessarily, but there are excellent peer reviewed data showing that indeed if you use smelling salts, which are mostly of the sort that include ammonia, ammonia is a very toxic scent. But it's toxic in a way that triggers this innate pathway, the pathway from the nose to the amygdala and wakes up the brain body in a major way. This is why they use smelling salts when people pass out. This is why fighters use to use or maybe sometimes still use smelling salts in order to heighten their level of alertness. This is why power lifters will inhale smelling salts. They work because they trigger the fear and kind of overall arousal systems of the brain. This is why I think most people probably shouldn't use ammonia or smelling salts to try and wake up, but they really do work. If you ever smelled smelling salts and I have, I tried this. They give you a serious cholt. It's like six espresso infused into your bloodstream all at once. You are wide awake immediately. And you feel a heightened sense of kind of desire to move because you release adrenaline into your body. Now inhaling through your nose and doing nasal breathing is not going to do that. It's going to be a more subtle version of waking up your system of alerting your brain overall. And for those of you that are interested in having a richer, a more deep connection to the things that you smell and taste, including other individuals perhaps, not just food. Practicing or enhancing your sense of sniffing your ability to sniff might sound like a kind of ridiculous protocol, but it's actually a kind of fun and cool experiment that you can do. You just do the simple experiment of taking, for instance, an orange, you smell it, try engage your level of perception of how orangeish it smells or lemon. Lemonish lemon. I don't know. Is it lemonish or lemon? Lemon. It smells then set it away. Do 10 or 15 inhales. Follow by exhales, of course, or just through the nose. Not going to do all 10 or 15 and then smell it again. You'll notice that your perception of that smell, the kind of richness of that smell will be significantly increased. And that's again, for two reasons. One, the brain is in a position to respond to it better. Your brain has been aroused by the mere act of sniffing, but also the neurons that respond to that lemon odor, that lemon eat or odor are going to respond better. So you can actually have a heightened experience of something. And that, of course, will also be true for the taste system. You also can really train your sense of smell to get much, much better when Nome Sobbl's group was at Berkeley. I haven't been a graduate student around that time. And every once in a while, I'd look outside and there would be people crawling around on the grass with goggles on, gloves on, and these hoods on with earmuffs. And they looked ridiculous. But what they were doing is they were actually learning to follow scent trails. So in the world of dogs, you have sight hounds that use their eyes in order to navigate and find things. And you have scent hounds that use their nose. And the scent hounds are remarkable. They can be trained to detect a scent. These are the sniffing, you know, the bomb sniffing and the drug sniffing dogs in airports. There are now dogs actually that can sniff out COVID infections with a very high degree of accuracy. They can be trained to that. There's something about the COVID and similar infections that the body produces probably in the immune response. Some odors and the dogs are, I think as high as 90% in some cases, maybe even 95% accuracy just remarkable. There are theories that dogs can sniff out cancer. This stuff all exceeds statistical significance. It's still a little bit mysterious in some ways. But you may not ever achieve the olfactory capabilities of a scent town. But what Nome Sobles lab did is they had people completely eliminate their visual experience by having them wear dark glasses or goggles. So they couldn't see and they couldn't hear they couldn't sense anything with with their sense of touch. They have thick gloves on, but they had these masks on were just their nasal passages were open and people could in a fairly short amount of time learn to follow a chocolate scent trail on the ground, which is not something that most people want to do. But what they showed using brain imaging, etc and subsequent studies is that the human brain you can learn to really enhance your sense of smell and become very astute in distinguishing whether or not one particular odor combinations of odors is such that it's less than or more than a different odor, for instance. Now why would you want to do this? Well, if you like to eat as much as I do, one of the things that can really enhance your sense of pleasure from the experience of ingesting food is to enhance your sense of smell. And if you don't have a great sense of smell or if you have a sense of smell that's really so good that it's always picking up bad odors, we'll talk about that in a minute. Well, then you might want to tune up your sense of smell by doing this practice of 10 or 15 breaths, excuse me, sniff, not breaths, sniff and then interacting with some food item or thing that you're interested in smelling more of. So these could be the ingredients that you're cooking with. I really encourage you to try and really smell them. You sometimes hear this as kind of a mindfulness practice like, ooh, really smell the food, really taste the food. And we always hear about that as kind of a mindfulness and presence thing, but you actually can increase the sensitivity of your old factory and your taste system by doing this. And it has long term effects. That's what's so interesting. This isn't the kind of thing that you have to do every time you eat. You don't have to be the weirdo in the restaurant that's like picking up the radish and jamming it up your nostrils. Please don't do that. You don't have to necessarily smell everything, although it's nice sometimes to be to smell the food that you're about to eat and as you eat it. But it has long term effects in terms of your ability to distinguish and discriminate different types of odors. And these don't even have to be very pungent foods that turns out the studies show that doesn't have to be some really stinky cheese. There are cheese shops that I've walked into where I just basically gag. I can't handle it. I just can't be in there. It's just overwhelmed me. Other people they love that smell. So you have to tune it to your interest and experience, but I think even for you, faster is out there. Everybody eats at some point. Everybody ingests chemicals through their mouth and one of the ways that you can powerfully increase your relationship to that experience and make it much more positive is through just the occasional practice of 10 or 15 sniff of nothing, which almost sounds ridiculous. Like how could that be? But now you understand why it's because of the way that the sniffing action increases the alertness of the brain as well as increasing the sensitivity of the system. No other system that I'm aware of in our body is as amenable to these kinds of behavioral training shifts and allow them to happen so quickly. I would love to be able to tell you that just doing 10 or 15 near far exercises with a pen or going outside for 10 or 15 seconds each morning is going to completely change the way that you see the world. But it actually isn't the case. You actually requires more training, a little bit more effort in the visual system in the olfactory system in your smell system and in your taste system. Just the tiniest bit of training and attention and sniffing, inhaling can radically change your relationship to food such that you actually start to feel very different as a consequence of ingesting those foods as well as becoming more discerning about which foods you like and which ones you don't like. I'm going to talk about that because there's a really wonderful thing that happens when you start developing a sensitive palate and a sensitive sense of smell in a way that allows you to guide your eating and smelling decisions and maybe even interpersonal decisions about who you spend time with or mate with or whatever in a way that is really in line with your biology. In fact, how well we can smell and taste things is actually a very strong indication of our brain health now that's not to say that if you have a poor sense of smell or a poor sense of taste that you're somehow brain damage or you're going to have dementia, although sometimes early signs of dementia or loss of neurons and other regions of the brain related to say Parkinson's can show up first as a loss of sense of smell. Again, it's not causal and it's certainly not the case that every time you have a sudden loss of smell that knows necessarily brain damage, I want to be very clear about that, but they are often correlated. There's also a lot of interest right now in loss of sense of smell because one of the early detection signs of COVID-19 was a loss of sense of smell. So I just briefly want to talk about loss of sense of smell and regaining sense of smell and taste because these have powerful implications for overall health and in fact can indicate something about brain damage and can even inform how quickly we might be recovering from something like a concussion. So our olfactory neurons, these neurons in our nose that detect odors are really unique among other brain neurons because they get replenished throughout life. They don't just regenerate, but they get replenished. So regeneration is when something is damaged and it regrows. These neurons are constantly turning over throughout our lifespan. They're constantly being replenished, they're dying off and they're being replaced by new ones. This is an amazing aspect of our brain that's basically unique to these neurons. One other region of the brain where there's a little bit of this maybe, but these olfactory neurons about every three or four weeks, they die. And when they die, they are replaced by new ones that come from a different region of the brain. A region called the subventricular zone. The name isn't as important, but as the phenomenon, but these neurons are born in the ventricle, the area of your brain that's a hole that contains, it's not an empty hole, it's a hole basically that contains cerebral spinal fluid. Well, there's a little subventricular zone. There's a little zone below subventricles. And that zone, if you are exercising regularly, if your dopamine levels are high enough, those little cells there are like stem cells. They are stem cells and they spit out what are called little neuroblasts, those little neuroblasts migrate into the front of your brain. And then, shimmy, they kind of move through what's called the rostral migratory stream. They kind of shimmy along and land back in your olfactory bulb, settle down and extend little wires into your olfactory mucosa. This is an ongoing process of what we call neurogenesis or the birth of new neurons. Now, this is really interesting because other neurons in your cortex, in your retina, in your cerebellum, they do not do this. They are not continually replenished throughout life. But these neurons, these olfactory neurons are, they are special. And there are a number of things that seem to increase the amount of olfactory neuron neurogenesis. There is evidence that exercise, blood flow, can increase olfactory neuron neurogenesis. Although those data are fewer in comparison to things like social interactions or actually interacting with odorants of different kinds. So if you're somebody who doesn't smell things well, you have a poor sense of smell. Your olfactory system doesn't seem very sensitive. More sniffing, more smelling is going to be good. And then the molecule dopamine, this neuromodulator that is associated with motivation and drive. And in some cases, if it's very, very high with mania or if it's very, very low with depression or Parkinson's. But for most people where dopamine is in essentially normal ranges, dopamine is also a powerful trigger of the establishment of these new neurons and their migration into the olfactory bulb and your ability to smell. Now you don't want to confuse correlation with causation. So if you're not good at smelling, does that mean you have low dopamine? No, not necessarily. If you have low dopamine, does that mean that you have a poor sense of smell? No, not necessarily. Some people who take antidepressants of the sort that impact the dopamine system strongly like well, butrin will report a sudden meaning within a couple of days increase in their ability to smell particular odors. And it's a very striking effect. Some people when they are in a new relationship because dopamine and the hormones testosterone and estrogen are associated with novelty and the sorts of behaviors that often are associated with new relationships. Those three molecules dopamine testosterone and estrogen kind of work together and oftentimes people will say or report when they're newly in love or in a new relationship that they're just obsessed with or they just so enjoy the scent of another person so much so that they like to borrow the other person's clothing or they'll sniff the other person's clothing or they can even just in the absence of the person they can imagine their smell and feel a biological response. Something that we'll talk more about. So these neurons turn over throughout the lifespan and as we age, we actually can lose our sense of smell and it's likely. I want to underscore likely that that loss of sense of smell as we age is correlated with the loss of other neurons in the retina in the ears, a loss of vision, loss of hearing, loss of smell, loss of the sense apparatus, which are neurons is correlated with aging. So what we've been talking about today is the ability to sense these odors but what I'd like to do is empower you with tools that will allow you to keep these systems tuned up. Last time we talked about tuning up and keeping your visual system tuned up and healthy regardless of age. Here we're talking about really enhancing your olfactory abilities, your taste abilities as well by interacting a lot with odors, preferably positive odors and sniffing more, inhaling more, which almost sounds crazy but now you understand why even though it might sound crazy, it's grounded in real mechanistic biology of how the brain wakes up and responds to these chemicals. Now speaking of brain injury, olfactory dysfunction is a common theme in traumatic brain injury for the following reason. These olfactory neurons, as I mentioned, extend wires into the mucosa of the nose but they also extend a wire up into the skull and they extend up into the skull through what's called the cribiform plate. It's like a Swiss cheese type plate where they're going through and if you get a head hit that bone, the cribiform plate shears those little wires off and those neurons die. Now eventually they'll be replaced but there's a phenomenon by which concussion and the severity of concussion and the recovery from a head injury can actually be gauged in part, not in whole but in part by how well or fully one recovers their sense of smell. So if you're somebody that unfortunately is suffered a concussion, your sense of smell is one read out by which you might evaluate whether or not you're regaining some of your sensory performance. Of course there will be others like balance and cognition and sleep, etc. But I'd like to refer you to a really nice paper which is entitled olfactory dysfunction in traumatic brain injury, the role of neurogenesis. The first author is Marin M.A.R.I.N. The paper was published in Current Allergy and Asma Report. This is 2020. I spent some time with this paper. It's quite good. It's a review article. I like reviews if they're peer reviewed reviews and in quality journals. And what they discuss is and I'll just read here briefly because they said it better than I could olfactory functioning disturbances are common following traumatic brain injury, TBI and can have a significant impact on the quality of life. Although there's no standard treatment for patients with with the loss of smell. Now I'm paraphrasing post injury olfactory training has shown promise for beneficial effects. Some of this involves they go on to tell us the role of dopamine dopaminergic signaling as I mentioned before. But what does this mean? This means that if you've had a head injury or repeated head injuries that enhancing your sense of smell is one way by which you can create new neurons. Now you know how to enhance your sense of smell by interacting with things that have an odor very closely and by essentially inhaling more focusing on the inhale to wake up the brain and to really focus on some of the nuance of those smells. So you might do for instance a smell test by which you smell something like a lemon, put it down, do 10 inhales or so smell again, etc. You might also just take a more active role in trying to taste and smell your food and taste and smell various things. I mean please don't ingest anything that's poisonous so you're not supposed to be ingesting. But you know what I mean? Really tuning up the system. I think it's an excellent review. We're going to do an entire episode all about the use of the visual system in particular. But also the olfactory system for treatment of traumatic brain injury as well as other methods. But I wanted to just mention it here because a number of people ask me about TBI. And here again we're in this place where the senses and our ability to sense these chemicals to these two holes in the front of our face are nostrils is a powerful readout and way to control brain function and nervous system function generally. Just a quick note about the use of smelling salts. I have a feeling that some of you may be interested in that and its application. If you are interested in that, I recommend you go to the scientific literature first rather than straight to some vendor or to the one of they call it these days, Castillo, bro science. He says bro science, the bro science. You can go to this paper, which is excellent and is real science, which is acute effects of ammonia and halense on strength and power performance in trained men. It's a randomized control trial is published in the journal strength and conditioning research in 2018. And it should be very easy to find. I will provide a link to the so called PubMed ID, which is a string of numbers and we'll put that in the caption if you want to go straight to that article does show a significant. What they call this is what the words they use literally in quotes, psyching up effect through the use of these ammonia and halense and a significant increase in maximal force and forced development in a variety of different movements. So for those of you that are interested in ammonia and halense so called smelling salts that might be a good reference. The other thing I wanted to talk about with reference to odors is this myth, which is that we don't actually smell things in our dreams that we don't have a sense of smell. That's pure fiction. I don't know who came up with that. It's very clear that we are capable of smelling things in our sleep. However, when we are in REM sleep, rapid eye movement sleep, which is the sleep that predominates toward the second half of the night. Our ability to wake up in response to odors is diminished. It's not absent, but it's diminished. If smoke comes into the room, we will likely wake up if the concentration of smoke is high enough regardless of the stage of sleep we're in. But in REM sleep, we tend to be less likely to smell, to sniff. That actually was measured in a number of studies that sniffing in sleep is possible. So if you put an odor like a lemon underneath someone's nostrils in the early portion of the night, they will smell. They will smell or not, I guess depends on them. They will smell or not. They will smell or not. They will smell or not. They will smell or not. They will smell or not. Especially if you wake them up soon after that they had a dream or a percept of a scent of a lemon. Later in the night, it's harder for that relationship to be established. It's likely that because of some of the paralysis associated with rapid eye movement sleep, which is a healthy paralysis, so called sleep atonia, you don't want to act out your dreams in REM sleep, that there is a less active tendency to sniff. And actually this has real clinical implications, the ability to sniff in response to the introduction of an odor is actually one way in which clinicians assess whether or not somebody's brain is so called brain dead. That's not a nice term, but brain dead or whether or not they have the capacity to recover from things like coma and other states of deep unconsciousness or I guess you call it subconsciousness. So what will happen is if someone has an injury and they're essentially out cold, the production of a sniffing reflex or a sniffing response to say a lemon or some other odor presented below the nostrils is considered a sign that the brain is capable of waking up. Now that's not always the case, but it's one indication. So just like you could use mechanic, mechanosensation, so a toe pinch, for instance, or scraping the bottom of somebody's barefoot to see if they're conscious or shining light in their eyes. These are all things that you've seen in movies and television or maybe you've seen in real life as well. Well, odors and chemical sensing is another way by which you can assess whether or not the brain is capable of arousal and actually olfactory stimulation is one of the more prominent ones that's being used in various clinics. As a last point about specific odors and compounds that can increase arousal and alertness, and this was simply through sniffing them, not through ingesting them, there are data, believe it or not, there are good data on peppermint and the smell of peppermint. Minty type sense, whether you like them or not, will increase attention and they can create the same sort of arousal response, although not as intensely or as dramatically as ammonia salts can, for instance. By the way, please don't go sniff real ammonia. You could actually damage your olfactory epithelium. If you do that too close to the ammonia, if you're going to use smelling salts, be sure you work with someone or you know what you're getting and how you're using this, you can damage your olfactory pathway in ways that's being used. You can also damage your vision. You've ever teared up because you inhaled something that was really noxious, that is not a good thing. It doesn't mean you necessarily cause damage, but it means that you have irritated the mucosal lining and you know, possibly even the surfaces of your eyes. So please be very, very careful. Sense like peppermint, like these ammonia smelling salts, the reason they wake you up is because they trigger specific olfactory neurons that communicate with the specific centers of the brain, namely the amygdala and associated neural circuitry and pathways, that trigger alertness of the same sort that a cold shower or an ice bath or a sudden surprise or a stressful text message would evoke. Remember, the systems of your body that produce a rousal end alertness and attention and that cue you for optimal learning, aka focus, those are very general mechanisms. They involve very basic molecules like adrenaline and epinephrine, same thing actually adrenaline epinephrine. The number of stimuli, whether it's peppermint or ammonia or allowed blast, the number of stimuli that can evoke that adrenaline response and that wake up response are near infinite. And that's the beauty of your nervous system. It was designed to take any variety of different stimuli, place them into categories and then evoke different categories of very general responses. Now you know a lot about olfaction and how the sense of smell works. Here's another experiment that you can do. I'll ask you right now. Do you like hate or are you indifferent to the smell of microwave popcorn? Some people, including one member of my podcast staff, says it's absolutely disgusting to them. They feel like it's completely nauseating. I don't mind it at all. In fact, I kind of like it. I think the smell of microwave popcorn is kind of pleasant. I don't particularly like it, but it's certainly not unpleasant. Some people have a gene that makes them sensitive to the smell of things like microwave popcorn such that it smells like vomit. I probably don't have that gene because I find the smell of microwave popcorn pretty pleasant. Some people hate the smell of cilantro. Some people ingest asparagus. And when they urinate, they can smell the asparagus in a very pungent way. Other people can't smell it at all. These are variants in genes that encode for what are called olfactory receptors. Each olfactory sensory neuron expresses one odorant gene, one gene that codes for a receptor that responds to a particular odor. If you don't have that gene, you will not respond to that odor. The reason why some people find the smell of microwave popcorn to be very noxious, putrid, in fact, is because they have a gene that allows them to smell the kind of putrid odor within that. Other people who lack that gene just simply can't smell it. So we are not all the same with respect to our sensory experience. What one person finds delicious, another person might find disgusting. I'll give a good example, which is that I absolutely despise Gorgonzola and blue cheese. Absolutely despise it. It smells and tastes like dirty moldy socks to me. Some people love it. They crave it. Actually, some people get a visceral response to it. We will talk about how certain tastes can actually evoke very deep biological responses, even hormonal responses when we talk about taste in a few minutes. But there are these odors, for instance, in popcorn, it's the molecule to acetylone pyroline, not proline, but pyroline that gives off to some people, like me, a toasted smell as the sugars in the kernels heat. The compound is also found in things like white bread and jasmine rice, which don't have as punch into an odor. But some people smell that and it smells like cat urine. Now there are sense, like musky sense and musty sense, that are secreted by animals like skunks and other animals of the so-called mustalid family. So these would be ferrets and other animals that can spray in response to fear or if they just want to market territory because they want to say that's mine. Dogs, incidentally, have sent glands that they rub on things, cats have them too. This musty odor, some people find actually quite pleasant. Some people find it to be very noxious. And that will depend, of course, on the concentration. I'll never forget the first time, Costello got sprayed by a skunk and it was awful. I actually don't mind the smell of skunk at a distance. It's actually a little bit pleasant. I admit it's a little bit pleasant to me. Not only that makes me too weird because if you ever read the book, all's quiet on the western front about World War I. There's a description in there about the smell of skunk at a distance being mildly pleasant. So the author of that book probably shared a similar olfactory profile to me or I to them rather. But some people find even the tiniest bit of the smell of skunk or must to be noxious or awful. High concentrations, it's really awful. And unfortunately poor Costello, he was literally red-eyed and just snorting and it was awful. There's a joke about dogs that says it dogs either get skunked one time and never again or 50 or 100 times. Costello has been skunked no fewer. I'm not making this up. And skunked no fewer than 103 times. And that's because if he sees something or hear something in the bushes, he just goes straight in. He does not learn. But if you like the musty scent or musky scent. Well, that says something about the genes that you express in your olfactory neurons. It is in completely inherited. And if you don't like that scent, if it's really noxious or you have this response to microwave popcorn, well that means you have a different complement, a different constellation, if you will. And there are some genes that make up for these olfactory sensory neurons and the receptors that they express. Let's talk about taste. Not whether or not you have taste or you don't have taste. There's no way for me to assess that. But rather how we taste things, meaning how we sense chemicals in food and in drink. There are essentially five, but scientists now believe there may be six things that we taste alone or in combination. They are sweet taste, salty taste, bitter taste, sour taste, and umami taste. Most of you have probably heard of umami by now. It's UMA M.I. Umami is actually the name for a particular receptor that you express on your tongue that detects savory taste. So it's the kind of thing in brazed meats. Sometimes people can even get the activation of umami by tomatoes or tomato sauces. What are each of these taste and taste receptors responsible for and then we'll talk about the sixth maybe you can guess what it is. I don't know if you can guess it now. I couldn't guess it. But of the five tastes each one has a specific utility or function. Each one has a particular group of neurons in your mouth in your tongue, believe it or not, that responds to particular chemicals and particular chemical structures. It is a total myth, complete fiction that different parts of your tongue harbor different taste receptors. That high school textbook diagram that you know sweet is in one part of the tongue and sour is in another and bitters in another complete fiction, just total fiction related to very old studies that were performed in a very poorly controlled way. No serious biologists and certainly no one that works on taste would contend that that's the way that the taste receptors are organized. They are completely intermixed along your tongue. If you have heightened or decreased sensitivity to one of those five things I mentioned sweet salty bitter umami or sour at a one location in your tongue it likely reflects the density of overall receptors or something going on in your brain, but not the differential distribution of those receptors. So the sweet receptors are neurons that express a receptor that respond to sugars in the same way that you have cones, photoreceptors in your eye that respond to short medium or long wavelength light meaning blue, ish, green ish or red ish light you have a neuron in or neurons plural in your tongue that respond to sugars. And then those neurons they don't say sweet they don't actually send any sugar into the brain they send what we call a volley a barrage of action potentials of electrical signals off into the brain. It's an amazing system. So all these receptors in your tongue make up what are called the neurons that give rise to a nerve a collection of wires nerve bundles of what's called the gustatory nerve it goes from the tongue to the so called nucleus of the solitary tracks and some of the requested names I usually don't like to include too many names for sake of clarity, but the gustatory nerve from the tongue goes to the nucleus of the solitary track and then to the stalemus and to insular cortex you don't have to remember any of those names if you don't want to but if you want mechanism you want neural circuits that's a circuit gustatory nerve from the tongue nucleus is solitary track in the brain stem them the phalamus and then insular cortex and it is an insular cortex this regenerate cortex that we sort out and make sense of and perceive the various taste. Now it's amazing because just taking a little bit of sugar or something sour like a little bit of lemon juice and touching it to the tongue within 100 milliseconds right just 100 milliseconds far less than one second you can immediately distinguish that sour that sweet that's bitter that's umami and that's an assessment that's made by the cortex now what to say is that we have these different five receptors in code for well sweet salty bitter umami sour but what are they really looking for what are they sensing well sweet stuff signals the presence of energy of sugars and while we're all trying or we're told that we have a variety of reasons the ability to sense whether or not a food has rapid energy source or could give rise to glucose is essential so we have sweet receptors the salty receptors these neurons are trying to sense whether or not there are neutral lights in a given food or drink electrolytes are vitally important for the function of our nervous system and for our entire body sodium is what allows neurons to fire what allows them to be electrically active we also need potassium and magnesium those that allow the neurons to be active so the salty receptors the reason that they are there is to make sure that we are getting enough but not too much salt we don't want to ingest things that are far too salty bitter receptors are there to make sure we don't ingest things that are poisonous how do I know this how can I say that even though I was definitely not consulted at the design how can I say that well the bitter receptors create a what we call labeled line a unique trajectory to the neurons of the brainstem that control the the gag reflex if we taste something very bitter it automatically triggers the gag reflex now some people like bitter tastes I actually like the taste of bitter coffee children generally like sweet taste more than bitter taste even babies if they taste something bitter they'll just immediately spit it up as a like the gag reflex putrid smells will also evoke these same neurons so some people are very sensitive they have a very sensitive or low threshold vomit reflex there was somebody in my lab early on we never did this intentionally we're just laughing because it was so dramatic we would have a discussion someone would say something about something kind of gross appropriate for the workplace but nonetheless gross we are biologists would say something and they would say stop stop I'm going to throw up you know and some people have a very low threshold quick gag reflex other people don't other people have a very stable stomach they don't that you know they've rarely if ever vomit the umami receptor isn't sensing savory because the body loves savory it's because savory is a signal for the presence of amino acids and we'll talk more about this but the presence of amino acids in our gut and in our digestive system and the presence of fatty acids is essential there is in fact no essential carbohydrate or sugar I'm not a huge proponent of ketogenic diets nor am I against them I think it's highly individual you have to decide what's right for you but everybody needs amino acids to survive the brain needs them and we need fatty acids especially to build a healthy brain during development you need amino acids and fatty acids and the sour receptor why would we have a sour receptor so that we could have those really like sour candies I think they've gotten more and more sour over the years I admit I don't eat candy much but I do have a particular weakness for like a really good really sour like gummy peach or they if the gummy cherries are dipped in whatever that sour powder so I was a kid who I admit it I like the lick a made thing I like drink the powder please don't do this don't give this garbage to your kids but I liked it it was tasty but sour receptors are not there so that you can ingest gummy sour gummy peaches or something like that that's not way that the system evolved it's there and we know it's there to detect the presence of spoiled or fermented food fermented fruit has a sour element to it and fermented things while certainly some fermented foods like sour crout and kimchi and things of that sort can be very healthy for us and are very healthy and reducing inflammation they're great data on that pro quality microbiome et cetera fermented fruit can be poisonous right alcohols are poisonous in many forms to our system and the sour receptor bearing neurons communicate to an area of the brain stem that evokes the pucker response closing of the eyes and essentially shutting of the mouth and cringing away I think cringe is like a thing now my niece whenever I seem to say something or do something it's either an I roll a cringe or both in combination so the sour the sweet the salty the bitter and the umami system we're not there so that we could have this wonderful palate of foods that we enjoy so much they'll allow us to do that but they're there to make sure that we bring in certain things to our system and that we don't ingest other things now what's the sixth sense within the taste system not six sense generally but within the taste system what's this punitive possible sixth receptor I already kind of hinted at it when I talked about fatty acids there are now data to support the idea although there's still more that needs to be done that we also have receptors on our tongue that sense fat and that because fat is so vital for the function of our nervous system and the other organs of our body that we are sensing the fat content in food maybe this is why I can only eat half but no less than half of a jar of almond butter or peanut butter in one sitting I just can't unless it's not salt in which case it makes no sense to me but it's remarkable how that texture and also the flavor but that texture of fat I love butter I am guilty and Costello is definitely guilty of eating parts of butter from time to time I have no guilt about this people eat parts of cheese why shouldn't we eat a pat of butter if you think that's gross then maybe I have greater abundance of the fat receptors in my tongue maybe I have a fat tongue then you do but nonetheless the ability to sense fat here in our mouth seems to be critical you can imagine why that is I want to talk about the tongue and the mouth as an extension of your digestive tract I know that might not be pleasant to think about but when you look at it through the lens that I'm about to provide it will completely change the way you think about the gut brain and about all the stuff that you've heard in these recent years about oh you know we have the second brain it's all these neurons in our gut I've been chuckling through these last few years as people have gotten so excited about it about the gut brain not because of their excitement I think the excitement is wonderful but we always knew that the nervous system extended out of the brain and into the body and people seem kind of overwhelmed and surprised by the idea that we have neurons in our gut that can sense things like sugars and fatty acids and I think those are beautiful discoveries don't get me wrong Diego Borges lab out of Duke University has done beautiful study showing that within the mucosal lining of our gut we have neurons in our gut and we have thousands of healthy and healthy skin cells and the brain that can be used to treat the blood and the skin and the blood in your mouth is a lot more than that and that's what I think you should do. out of Duke University has done beautiful studies showing that within the mucosal lining of our gut we have neurons that sense fatty acids, sugars, and amino acids, and that when we ingest something that contains one or two or three of those things there's a signal sent via the vagus nerve up into what's called the no-dose ganglion, N-O-D-O-S-E, and then into the brain where it secretes dopamine, which makes us want more of that thing. It makes us more motivated to pursue and eat more of that thing that's either fatty or umami, it's savory, or has a sweet taste. Anyone or two or three of those qualities, independent of the taste. Now I think those are beautiful data but we know that this thing, the mouth, if those you listening, I'm just got my fingers in my mouth, that's why I sound like I'm, that's something in my mouth. This thing in front of our face, we use it for speaking, but it is the front of our digestive tract. We are essentially a series of tubes and that tube starts with your mouth and heads down into your stomach and so that you would sense so much of the chemical constituents of the stuff that you might bring into your body or they might want to expel and not swallow or not interact with by being able to smell it, is it putrid, does it smell good, does it taste good, is this safe, is it salty, is it so sour that it's fermented and is going to poison me, is it so bitter that it could poison me, is it so savory that yes, I want more and more of this, well then you'd want to trigger dopamine, that's all starting in the mouth. So you have to understand that you were equipped with this amazing chemical sensing apparatus, we call your mouth and your tongue and those little bumps on your tongue that they call the papillet, those are not your taste buds, surrounding those little papillet, like little rivers, are these little dense and indentations and what dense and indentations do in a tissue is they allow more surface area, they allow you to pack more receptors. So down in those grooves are where all these little neurons and their and their little processes are with these little receptors for sweet salty bitter umami sour and maybe fat as well. So it's this incredible device that you've been equipped with that you can use to interact with various components of the outside world and decide whether or not you want to bring them in or not. Just as you can lose those olfactory neurons if you happen to get hit on the head or you have some other thing maybe it was an infection that caused loss of those olfactory sensory neurons, you can also lose taste receptors in your mouth. If you've ever eaten something that's too hot, not spicy hot but too hot, you burn your tongue, you burn receptors. It takes about a week to recover those receptors. For some people it's a little bit more quickly but if you burn your tongue badly by ingesting a soup that's too hot or a beverage that's too hot, you will greatly reduce your sense of taste for essentially all tastes and that's because those neurons sit very shallow beneath the tongue surface and so that if you put something too hot on you literally just burn those neurons away. Luckily those neurons also can replenish themselves. Those neurons are of the peripheral nervous system and like all peripheral system neurons they can replenish or regenerate. So if you burn your mouth in about a week or so hopefully sooner you'll be able to taste again. In fact everybody's ability to taste is highly subject to training. You can really enhance your ability to taste and taste the different component parts of different foods. Simply by paying attention to what you're trying to taste. This is an amazing aspect of the taste system. I think more than any other system, the taste system and perhaps the smell system as well can be trained so that you can learn to pick out the tones if you will of different ice cream or different beverages. Somebody who I don't drink much alcohol, I occasionally have a drink or something but you know a while ago I got to taste a bunch of different white tequila. These are different kinds of tequila that are not brown. They're white and I sort of assumed that all tequila was disgusting. That was my assumption before doing this and then I tasted a couple white tequila and I realized that those aren't too bad. I tasted a few more and then pretty soon I could really start to detect the nuance and the difference. Now I haven't had tequila in a long time now. I sort of tend to not drink it all these days but in a very short period of time like a couple of days I got very good at detecting which things I liked and I could start to pick out tones. So I'm not a wine drinker but for those of you that are you know you hear about oh you know it has floral tones or berry tones or chocolate tones. You know some of that is just kind of menu based and kind of marketing based silliness designed to get you excited about what you're about to ingest but some of it is real and for people that are skilled in assessing wines or assessing foods much more of an eater than a drinker. You can really start to develop a sensitive palette a nuanced palette through what we call top-down mechanisms. This olfactory cortex that takes these five maybe the sixth fat receptor two information and tries to make sense of what's out there in the world and what what its utility is is it good is it bad or I want more of it or less than it. That neural circuitry is unlike other neural circuitry in that it seems very amenable to behavioral plasticity for whatever reason and we could talk about what those reasons might be. You know it's interesting sometimes to think about how your taste literally chemical taste is probably very different than that of other people. How a food taste to you is probably very different than how it tastes to somebody else. The same probably cannot be said of something like vision or hearing unless you're somebody who has perfect pitch or you're color vision is disrupted or your romantic shrimp chances are when we look at the same object two people are seeing more or less the same object or perceiving it in a very similar way. There are experiments that essentially establish that. Now we have taste receptors and a lot of those taste receptors the chemical structures are known they come with fancy names like the T1R1 or the T1R2 which were identified as the sweet and umami receptors. So what's interesting is that this umami flavor is the savory flavor rather that sense by umami receptors is very close to the receptor that detects sweet things. Similarly bitter is sensed by a whole other set of receptors. Now there's a fun naturally occurring experiment that will forever change the way that you look at animals and the way certainly that I think about dogs and costello in particular carnivorous large animals like tigers and some grizzly bears for instance. We know that they have no ability to detect sweet. They don't actually have the receptors for detecting sweet on their tongue but their concentration of umami receptors of their ability to detect savory is at least five thousand times that which it is in humans. In other words if I eat a little piece of steak or costello eats a little piece of steak that steak probably tastes much much more savory than it does to me. So dogs and tigers and bears etc they're going to taste savory things and smell savory things with a much higher degree of sensitivity but they can't taste sweet things. Other large animals which are mostly herbivores like the panda bear for instance. It's hard to believe that thing is even a bear. I got nothing against pandas I just think that they get a little bit too much of the limelight frankly. So no vendetta against pandas save the pandas. I hope they replenish all the pandas but pandas in all their whatever have no umami receptors. They can't taste savory but they have greatly heightened density of sweet receptors. So there they are eating these whatever bamboos all day or not bamboozle but bamboos all day and they can taste things that are very sweet with a much higher degree of intensity and in general animals that are more gentle more herb that are herbivores excuse me or animals that have the propensity for aggression that's where you really see the divergence of the umami receptor because it's associated with meat and amino acids and where you see the enhancement of the sweet receptors for animals that eat a lot of plants and fruits and they probably taste very different to them when they do to you and me. And so it's interesting to note that animals that eat meat that eat other organisms can actually extract more savory experience from that. What does this mean for you? All right. Do you associate yourself as a tiger or grizzly bear or panda or a combination of both? Most people are omnivores. However, you may find it interesting that people that for instance eat a pure carnivore type diet or a keto diet where they are ingesting a lot of meats. So therefore are sensing a lot of umami flavors. And I realize not everyone who's keto eats meat. But those who do that will develop a more sensitive palate and likely there are some data although early data craving for umami like foods. Whereas people that eat a more plant-based diet are likely developing a heightened sensitivity and desire for and maybe even dopamine response to sugars and plant-based foods. Now this is my partial attempt to reconcile the kind of online battle that seems to exist between plant-based versus animal-based purely plant-based or purely animal-based diets. I think most people are omnivores. But it's kind of interesting to think that the systems are plastic such that people might want more meat if they eat more meat. People might want more plants if they eat enough plants for a long period of time. And this might explain some of the chasm that exists between these two groups. Now this is not to say anything about the ethical or the environmental impacts of different things. I don't even want to get into that because the meat people say that the plant-based diets have as much a negative impact as the plant people say that the meat-based diets are that's a totally different discussion. What I'm talking about here is food craving and food seeking and one's ability to detect these umami savory flavors is going to be enhanced by ingesting more meat and less activation of the sweet receptor. So in other words the more you eat the more you're going to become like a tiger so to speak and the more that you avoid these umami flavors and meats and the more that you would eat plant-based foods and in particular sweet foods the more you will likely suppress that umami system and that you will have a heightened desire for appetite for and sensing of sweet foods or foods that contain sugars. What I'm about to tell you is going to seem crazy but is extremely interesting with respect to taste and taste receptors. Remember even though we can enjoy food and we can evolve our sense of what's tasty or not tasty depending on life decisions, environmental changes, etc. The taste system just like the olfactory system and the visual system was laid down for the purpose of moving towards things that are good for us and moving away from things that are bad for us. That's the kind of core function of the nervous system. Well taste receptors are not just expressed on the tongue. They are expressed in other cells and other tissues as well. Some of you may be able to imagine foods that are so delicious to you that they make your entire body feel good or foods that are so horrifically awful to think about let alone taste that they create a whole body shuddering or kind of repellent type response where you just either cringe or turn your face away even in the absence of that food. That's sort of how I feel about pungent Gorgonzola cheese. If you like Gorgonzola cheese I don't judge you. I just that's an individual difference. I happen to love certain foods. I do like savory foods very much. When I think about them they just they make me feel good and I'm oftentimes not even associating with the taste of those foods. It feels almost like a visceral thing. Well it turns out that some of the taste receptors extend beyond the tongue that they actually can extend into portions of the gut and digestive system. And if that's not strange enough turns out that some of the taste receptors are actually expressed on the ovaries and the testes. So what that means is that the gonads the very cells and tissues and organs in our body that make up the reproductive axis are expressing taste receptors. So how do we interpret this? Does this mean that when you eat something that's very savory or very sweet for instance that it's triggering activation of the ovaries or of the testes? Well it's possible. Now how those molecules those chemical molecules would actually get there is unclear. The digestive tract does not run directly to the testes or to the ovaries. But nonetheless what this means is that chemical sensing of the very things that we detect on our tongue and that we call taste in quotes in food is also evoking cellular responses within the reproductive gonads. Now whether or not this underlies the positive association that we have with certain foods isn't clear. But I'd be remiss if I didn't point out the obvious which is that the relationship between the sensual nature of particular foods and sensuality generally and the reproductive axis is something that's been covered in many movies. There are entire movies that are focused on the relationship between for instance chocolate and love and reproductive behaviors or certain feasts of meat and their wonderful tastes and the kind of sensuality around feasts of different types of foods but in general it's the sweet and the savory. Rarely is it the sour or the bitter the salty or the fat and not surprisingly perhaps it is the T2Rs and the T1Rs the receptors that are associated with the sweet and with the umami the savory flavors that are expressed not just on the tongue and in portions of the digestive tract but on the gonads themselves. So what does this mean does this mean that eating certain foods can stimulate the gonads maybe there's no data that immediately support that right now but this is an emerging area if you'd like to read more about this there's a great review entitled taste perception from the tongue to the testies although they do also talk about the ovaries why they didn't include that in the title is I think a reflection of the or bias of the author the author indicate not incidentally is Feng Lee last last name L.I. is a very interesting paper published in molecular human reproduction you can find it easily online it's downloadable also provide a link to it I just think it's fascinating that these taste receptors are expressed in other tissues and I should mention that they're expressed in tissues of other areas of the body as well including the respiratory system but the richest aggregation or concentration of these receptors from umami and sweet of course is on the tongue but also on the gonads and I think it does speak to the possible bridge between what we think of as a a sensory or a sensual experience of food and the deeper kind of visceral sense within the gut and maybe even within the gonads as well of something that we find extremely pleasurable or even a petitive that we want to move toward it we are actually going to return to that general theme in the discussion about touch sensation some people for instance when they touch certain surfaces like um furs or or sheep skins or velvet or soft smooth surfaces it feels good elsewhere in their body not just at the point of contact with that surface and similarly if there's the how about this one the screech of chalk on a chalkboard it's it's a it's a sound but it has a very strong visceral component or sandpaper like fingers fingernails on a chalkboard not the sound but the feeling right exactly so our whole nervous system is tuned to either be drawn toward a petitive or repelled by a aversive behaviors right so there's this push pull that exists and what I'm referring to in terms of these receptors on the tongue that are also expressed on the gonads is yet another example of what at least in this case seems to be an appetitive thing a desire to move toward certain foods and maybe even the experiences that are associated with those foods I want to talk about a particular aspect of food and a chemical reaction in cooking called the Mayard reaction some of you have probably heard of the Mayard reaction it's spelled M-A-I-L-L-A-R-D the D is silent so don't call it the mallard reaction and it's not the mallard reaction it is the Mayard reaction and the Mayard reaction is a reaction that for the aficionados is a non-enzymatic browning the other form of non-enzymatic browning is caramelization although when you hear caramel caramel I think it's caramel you think sweet and indeed caramelization is a sugar sugar chemical interaction that leads to a kind of nicely toasted not burnt but nicely toasted sweet taste whereas the Mayard reaction is that really savory reaction that occurs when you have a sugar amino acid reaction remember we have neurons in our gut but also neurons in our tongue and neurons deep in the brain that are comparing the amount of sugar to savory okay and the Mayard reaction is very interesting for you chemists out there this is going to be way too elementary and for you non-chemists it's probably going to be a little bit of a reach but just bear with me all these chemicals that we sense have a different structure it's like hydrogens and oxygens and aldehyde groups and all these things and basically the Mayard reaction involves what's called a free aldehyde if you didn't like chemistry don't worry about it it's basically got a group there that kind of sits open that allows it to interact with other things and actually through the use of heat and other process that we call brazing which I'll talk about in a moment you create a what's called a ketone group now most people now have heard of ketones because they think about the ketogenic diet but a ketone group is actually a chemical compound that can be used for energy that's why people say you can use ketones for energy but if you've ever actually encountered ketones if you for instance get liquid ketones a ketone ester and you smell it what does it smell like it smells a little bit like an alcohol but it has a kind of savory taste even when you smell it okay there are other smells that have these tastes too but for the Mayard reaction which could be created for instance like if you took a piece of meat or if you're not a meat eater if you took tomatoes and you cooked them in a pan and you cooked it nice and slow till it's simmered and almost started to brown and burn a little bit usually if I do it it burns I'm not a good cook let's cost a little points out a lot but it gets that like almost tangy very umami like flavor and sometimes it will even stick to the pan if you scrape it off it actually you can taste it in your mouth as you're cooking it that's the Mayard reaction that's that free aldehyde group and that's the production of a ketone group when you smell ketones it smells very much like that okay some people talk about the ketones I will produce like fruity breath and that's true if people are really far into ketosis their breath has a kind of fruity odor that's a little bit of a different thing so the relationship between smell and taste is a very very close one and this is why when people drink wine they often will inhale and then sip some of that is just kind of like pomp and circumstance frankly I make a big deal of it but they can sense things with their mouth the combination of odor receptors being activated in a particular way and taste receptors in the mouth being activated in a particular way triggers the activation of multiple brain areas that are associated with taste and circuitry within the body that's associated with the behaviors that relate to that taste like leaning toward it or leaning away from it depending on whether or not it's a petitive or aversive so the mayrd reactions a very interesting reaction involving this sugar amino acid thing but really it's what it's doing is heating up food such that the amino acids are more available literally in their chemical form for detection by the neurons this is a phenomenon that occurs in other domains of the taste system for instance a lot of what's happened with highly processed foods is that manufacturers have figured out how to trigger more dopamine response by ingestion of these sugary foods and created textures and created essentially design of foods for two purposes I'm not out to completely demonize processed foods I did that in a previous episode but processed foods are really designed to take foods that ordinarily would spoil that would have a shelf life and extend their shelf life to turn foods which are not a commodity into a commodity something to be stored and used essentially as a as a tradable purchasable sellable resource in doing that they change they've also decided to change the texture so that you want to chew more of them like I have this thing I don't know what it is for those um trisket crackers I don't why are those things so good it's probably the texture got those layers they're just kind of perfectly salty haven't had one in a long time so I bet if I had one now it wouldn't taste as good as I'm imagining it but those combinations of texture smell and taste are what combine to activate these different brain areas that make you really want to desire something and the people who make foods processed foods in particular are phenomenally good at figuring out what drives the dopamine system and makes you want more of these things either because of the way they taste and or because of the way they trigger neurons and you're got that have nothing to do with taste that simply make you desire more of the food in other words many of the foods that are processed foods make you desire more of them that it's impossible to eat one chip kind of thing not because they taste good but because in your gut they're activating the neurons that activate dopamine which make you seek more of those foods independent of blood sugar or anything else so you may actually be eating more of particular foods not because they taste good but because they feel good on your tongue and mouth and because the neurons in your gut which are totally independent of conscious taste are triggering the release of dopamine which is a molecule that makes you seek more of and do more of anything that led to the ingestion of that food there's a fun experiment that you can do which is to completely invert your sense of sweet and sour there's actually a way to do this readily when I was a postdoc I used to have a journal club at my house people come over in the evening once a month and we would read a paper typically the weirdest paper we could find and we would eat food and hang out as what nerds did and do for fun so that's what we did and one time someone brought what's called miracle berry okay so this isn't some psychedelic plant medicine thing miracle berry you can purchase online it's relatively inexpensive it actually causes a change in the configuration of taste receptors such that when you eat something sour it tastes sweet and so what's really wild is you ingest miracle berry and then you bite into a lemon maybe even the lemon peel and it tastes as sweet as a peach and this effect last several hours definitely you know check any warnings I don't know what sort of warnings these miracle berry carries but I'm sure there's always something you would you can imagine there are a number of papers on miracle berry or miracle fruit it's called but it changes your perception of sour at a perceptual level but it does that by changing the activity the receptors in the mouth and tongue now this is important as a principle and it's underscored by experiments that been done by for instance Charles Zucker's lab at Columbia University where they've essentially genetically engineered animals such that the bitter receptor is swapped with the sweet receptor or the sweet receptor is swapped with the bitter receptor and what they show is that the actual food the experience on the tongue drives different pathways in the brain here's what they did they essentially took mice and swapped out the sweet receptor and put in a bitter receptor and then what they found is that whereas normally mice would actively seek out and even work for sugar water sucrose they really like that if they replace the sweet receptor with the bitter receptor the mice would avoid sugar water and the verse was also true that mice would drink a bitter solution avidly they liked a bitter solution if they swapped out the bitter receptor for sweet receptor what this means is that our entire experience of what we taste is dependent on how we experience that taste of the level of the tongue and so you're hopefully not going to do genetic engineering of your taste receptors but if you'd like to do this sort of experiment you actually can do it very easily using miracle fruit the instructions of how much to ingest etc any safety concerns are usually on the package and should be easy to find and there's a lot of science to support how this works it's kind of a fun experiment that anyone can do and will completely change your perception of any food that you're accustomed to eating in fact you can figure out how much sweet or the sense of sweetness is contributing to your experience of a food even if you don't think of it as a sweet food through this miracle fruit experiment you could take miracle fruit you could be a slice of pepperoni pizza or cheese pizza which perhaps normally to you would taste just like pizza and you'll notice it tastes very different what you are detecting is how much the sense of sweet was contributing to that particular flavor now i'd like to return to pheromones so i mentioned earlier true pheromone effects are well established in animals and one of the most remarkable pheromone effects that's ever been described is one that actually i've mentioned before on this podcast but i'll mention again just briefly which is the coolage effect the coolage effect is the effect of a male of a given species in most cases it tended to be a rodent or a rooster mating and at some point reaching exhaustion or the inability to mate again because they just simply couldn't for whatever reason the coolage effect establishes that if you swap out the hen with a new hen or the female rat or mouse with a new one then the rat or the rooster spontaneously regains their ability to mate somehow their vigor is returned the refractory period after mating that normally occurs is abolished and they can mate again turns out that the coolage effect runs in the opposite direction too i did not know this but i recently learned of a study it was actually done in hamsters not in in mice but it turns out that females also will female rodents will mate to exhaustion and at some point at some point excuse me they will refuse to mate any longer unless you swap in a new male and then because mating in rodents involves the female being receptive there are certain number of behaviors that mean that she that tell you that she's willing and wanting to mate so-called lordrosis reflects then if there's a new male she will spontaneously regain the lordrosis reflex and the desire to mate and how do you know this how do we know it's a pheromonal effect well this recovery of the desire and ability to mate both in males and in females can be evoked completely by the odor of a new male or female it doesn't even have to be the presentation of the actual animal and that's how you know that it's not some visual interaction or some other interaction it's a pheromonal interaction now as i mentioned earlier pheromonal effects humans have been debated for a long period of time we are thought to have a vestigial meaning a kind of shrunken down miniature accessory olfactory bulb called jacobsons organ or the vomeronasal organ some people don't believe that jacobsons organ is this some people do there is anatomical evidence for it in some cadavers it sits not very high up in the brain or where your olfactory bulb is but it's actually in the nasal passages so there's a lot of little dents as you go up through your nasal passages and there is evidence of something that's vomeronasal like vomeronasal is the pheromonal organ they call it jacobsons organ if it's present in humans kind of tucked into some of the divots in the nasal passage even if that organ jacobsons organ isn't there or is not responsible for the chemical signaling between individuals there is chemical signaling between human beings as i mentioned earlier the effect of tears in suppressing the areas of the brain they're involved in sexual desire and testosterone of males that's a concrete result it's a very good result published by an excellent group with no preexisting bias going in that's just what they found there is also evidence both for and against chemical signaling between females in terms of synchronization of menstrual cycles now the original paper on this was published in the 1970s by McClendton and it essentially said that when women live together in group housing dormitories and similar that their menstrual cycles were synchronized and that was due to what was hypothesized to be pheromonal effects over the years that study has been challenged many many times the more recent data point to the idea that there is chemical chemical signaling between women in ways that impact the timing of the menstrual cycle but that depending on whether or not some of the women are in the ovulation phase the ovulatory phase of that cycle or whether or not they are in the follicular phase the phase when the follicle is maturing before the egg actually ovulates so two two separate phases of the 28 day menstrual cycle will either lengthen or shorten the menstrual cycle of the person that smells those women translate into English what that means is that it is very likely it seems that something maybe pheromones but maybe some other chemical that is independent of pheromones is being conveyed between women that are housed together or spend a lot of time together to shift their menstrual cycle but it doesn't necessarily mean that they synchronize so for instance if one woman is in the follicular phase of the menstrual cycle it might shorten or delay ovulation excuse me it might accelerate ovulation in another woman whereas if somebody is in the ovulatory phase of their cycle it might lengthen the menstrual cycle out so that they the woman who smells that person's scent or who smells her sweat we still don't know the origin of the chemical would ovulate later so all of this is to say is that chemical chemical signaling is happening from females to males through tears we know that is that a pheromonal effect well by the strict definition of a pheromone a molecule that's released from one individual that impacts the biology of another individual yes but in terms of identifying what the pheromone is in tears that's still unknown it's not clear what the chemical compound is so we're reluctant as scientists to call it a true pheromonal effect the menstrual cycle and the synchronization of the menstrual cycle effect seems to hold up under some conditions but in some cases there's a kind of clash of menstrual cycles that's created by chemicals that are emitted from one female to another so there are many examples of this in humans for instance people can recognize the t-shirt of their mate if you give this experiment has been done many times i know it's been challenged a number of times but the data are pretty good by now that if you offer you take a collection of women who are in stable relationships with somebody you offer them the smell of a hundred different shirts and they can very readily pick out their significant others scent okay that's pure olfaction that's not pheromonal but nonetheless is a remarkable degree of discrimination olfactory discrimination you can dilute their partner scent down to the point where they themselves can't consciously detect the difference between the sweat or the t-shirt of a hundred different t-shirts or so and they might say i don't really smell the difference but i think it's this one yeah this one belongs to the person that i've been with and they are much greater than chance at detecting the t-shirt or or identifying the t-shirt correctly so there's no question really that there is chemical chemical signaling between humans the question is whether or not it's truly pheromonal in basis now you'll notice that a lot of the examples i gave aside from the one of tears is women detecting the sense of men or of other women and it turns out that there are a number of papers the best one i think that i could find is published in physiology and behavior in 2009 to review entitled sex differences in reproductive hormone influences on human odor perception by dotty doty and camera and encourage you to check out this review it's available free as a download will provide a lot of link to it you can get the full pdf if you want but it does seem that women are better at detecting odors in these odor discrimination tasks than are men and yes that it does vary according to where they are in their menstrual cycle and yes they also looked at people who had received gonadectomy that had their ovaries removed a number of different important controls none of this surprises me none of this should surprise you it's very clear that hormones have a profound effect on a large number of systems in our biology and that smell and taste and the ability of sense the chemical states of others either consciously or subconsciously have a profound influence on whether or not we might want to spend time with them whether or not this is somebody that we're pair bonded with whether or not this is somebody that we just met and uh don't trust yet things of this sort and given what's at stake in terms of reproductive biology not just offspring but given the possibility of transmission of diseases etc uh you know the risks of childbirth etc it makes so much sense that much of our biology is wired toward detecting and sensing whether or not things and people are things that we should approach or avoid whether or not reproduction with that person is the appropriate response or suppression of the reproductive response is the appropriate response right as in that's case with the tears so I think these are fascinating studies it's an area that still needs a lot of work but there are some really wonderful papers on this and the one that I mentioned a few minutes ago sex differences in reproductive hormone influences on human odor perception is um one of the better reviews that are out there there are also a number of other reviews for instance that talk about pheromone effects and their impact on mood and sexual responses and things that sort and we will also provide some links to those a lot of this is still speculative but I want to say I know I said three times but I really want to underscore because it is vitally important and people seem to get a little triggered by the notion of pheromones just because we haven't identified the actual chemical compound that's acting as a pheromone or punitive pheromone does not mean that chemical chemical signaling between individuals doesn't exist clearly it does actually you and every other human from the time you're born until the time you die are actively seeking out and sensing and evaluating the chemicals that come from other individuals so really nice study that was done by the Whitesman Institute a group there I think it was also known Somal's group but another group as well as I recall looking at human human interactions when they meet for the first time it's a remarkable study because what they found was people would reach out and shake hands this is a typical response you know pre-pandemic people would meet they'd reach out and they would shake hands and what they observed was almost every time within just a few seconds of having shaken hands with this new individual people will touch their eyes almost without fail occasionally they would touch their eyebrow occasionally someone would touch their hair we always associate that with people having some sort of or us having some sort of self-conscious response like oh we want to make sure we're you know sure tucked in and all you know pre-man proper whatever it is or looking right is there's something in my teeth this kind of thing but actually people are doing that even if the person they just met left the room so someone sitting there someone comes in they shake hands and the person inevitably subconsciously touches their eyes they are taking chemicals from the skin contact and they are placing it on a mucosal membrane of some sort typically not up their nose or in their mouth typically on their eyes now animals do this all the time there's a phenomenon animals called bunting if you have a over-eager dog that when you meet them or you see them again after you've been away for the day they'll rub their head against you right cats will do this too it's called bunting they're rubbing their scent lands on you they're marking you and believe it or not you're marking other people when you shake their hand and they are then taking your mark and rubbing it on themselves subconsciously so we all do these kinds of behaviors and now that you're aware of it you can watch for it in your environment you can you know pay attention to people some of this is probably changed in light of the events of 2020 etc but nonetheless we are evaluating the molecules on people's breath we are evaluating the molecules on people's skin by actively rubbing it rubbing it on ourselves and we are actively involved in sensing not just their facial expressions the size of their pupils and things like that but the chemicals that they are emitting their hormone status how they smell we're detecting the pheromones possibly but certainly the odors in their breath you might say well I don't actually go around sniffing people's breath I don't you know unless if it's bad in which case it's aversive but breath is communicating a lot of signals and this handshake i-rub experiment shows that we are actively going through behaviors reflexively to wipe ourselves or smear ourselves with other people's chemicals now that might seem odd or even gross to you but I think it's beautiful I think that it illustrates the extent to which we as human beings are in some ways among the other animals in our subconscious sometimes conscious but certainly subconscious tendency to try and evaluate our chemical environment through what we inhale through our nose what we ingest through our mouth and what we actively take off other people's skin and rub on ourselves to evaluate it and what we should do about it and perhaps that person as well so today we talked a lot about olfaction taste and chemical sensing between individuals I like to think that you now know a lot about how your smell system works and why inhaling is a really good thing to do in general for waking up your brain and for cognitive function and for enhancing your sense of smell we talked about how to enhance your sense of taste and we talked about chemical signaling between individuals as a way of communicating some important aspects about biology people are shaping each other's biology all the time by way of these chemicals that are being traded from one body to the next through air and skin to skin contact and tears if you're enjoying this podcast and you're finding the information useful please subscribe on youtube that's one of the best ways to support us you can also put any questions you have and feedback in the comment section on youtube if you don't already subscribe on apple and Spotify you can support us by subscribing on apple and Spotify and on apple you get the opportunity to leave us a review up to five stars if you think we deserve five stars please give us a five star review in any case you can leave us comments there and we are also very active on instagram huberman lab on instagram is where i post yes clips from the podcast but also additional new and original content and you have the opportunity to put your questions in the comment section below those posts as well i do read all the comments on youtube on apple and also on instagram we have a website hubermanlab.com where all the podcasts are housed with links to youtube apple and Spotify as well as downloadable links everything zero cost of course and there you can also find any links to additional resources that we might post as well please check out our sponsors that we 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through that portal you get 20% off any of their things at checkout last but not least i want to thank you for your time and attention in your willingness to embrace new concepts and terms and to learn about science and biology and protocols that hopefully can benefit you and the people that you know and of course thank you for your interest in science