

Dr. Gina Poe: Use Sleep to Enhance Learning, Memory & Emotional State | Huberman Lab Podcast

My guest this episode is Gina Poe, PhD, a professor in the department of integrative biology & physiology at the University of California, Los Angeles (UCLA). We discuss her research exploring how sleep impacts learning, memory, hormones and emotions. She discusses tools to enhance your quality of sleep, increase deep sleep, rapid eye movement sleep and growth hormone release-- a key hormone for health, immune function and vitality. Dr. Poe explains how a specific brain area, the locus coeruleus, facilitates the processing of emotions, helps relieve traumas and how to maximize locus coeruleus function. She also explains sleep's vital role in opiate addiction recovery and how anyone can determine their optimal sleep timing and duration. This episode is rich with basic science information and zero-cost tools to enhance quality and effectiveness of sleep for sake of mental health, physical health and performance.

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Dr. Gina Poe

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Welcome to the Huberman Lab podcast, where we discuss science and science-based tools for everyday life, I'm Andrew Huberman and I'm a professor of neurobiology and Ophthalmology at Stanford school of medicine. Today my guest is Dr Gina Poe, Dr Gina Poe is a professor in the department of Integrative biology and Physiology at the University of California, Los Angeles. Her laboratory and research focuses on the relationship between sleep and learning, in particular how specific patterns of brain activity that are present during specific phases of sleep impact, our ability to learn and remember specific types of information, for instance, procedural information. That is how to perform specific cognitive or physical tasks, as well as encoding of emotional memories and discarding emotional

memories. Indeed, her research focuses on how specific phases of sleep can act as its own form of trauma therapy discarding the emotional tones of memories. In addition, her laboratory focuses on how specific phases of sleep impact things like the release of growth hormone, growth hormone, of course, plays critical roles in metabolism and tissue repair, including brain tissue repair, and therefore has critical roles in vitality and Longevity. Today you will learn many things about the relationship between sleep learning, emotionality and growth hormone, one basic, but very important, takeaway. That you'll learn about today, which was news to me, is that it's not just the duration and depth of your sleep that matter, but actually getting to sleep at relatively the same time. Each night ensures that you get adequate growth hormone release in the first hours of sleep. In fact, if you require, let's say eight hours of sleep per night, but you go to sleep two hours later than your typical bedtime On Any Given night. You actually miss the window for growth hormone release. That's right! Getting growth hormone release in sleep, which is absolutely critical to our immediate and long-term health, is not a prerequisite of getting sleep even if we are getting enough sleep as Dr Poe explains their critical brain circuit and endocrine. That is hormone circuits that regulate not just the duration and depth and quality and timing of sleep. But when we place our bout of sleep, that is when we go to sleep each night, plus or minus about a half hour or so strongly dictates whether or not we will experience all the health promoting including mind promoting benefits of sleep. Today's episode covers that and a lot more in substantial detail. You will learn, for instance, how to use sleep in order to optimize learning, as well as forgetting for those things that you would like to forget. So during today's episode, Dr Gina Poe shares critical information about not just Neuroscience but physiology and the hormone systems of the brain and body that strongly inform mental health, physical health and performance. So, by the end of today's episode, you'll be far more informed about sleep and how it works. The different roles it performs and you'll have several new actionable steps that

00:02:52 LMNT, Helix Sleep, Eight Sleep, Momentous

You can take in order to improve your mental health, physical health and performance before we begin I'd like to emphasize that this podcast is separate from my teaching and research roles at Stanford. It is, however, part of my desire and effort to bring zero cost to Consumer information about science and science related tools to the general public. In keeping with that theme, I'd like to thank the sponsors of today's podcast. Our first sponsor is element element is an electrolyte drink. That has everything you need and nothing you don't. That means plenty of salt, magnesium and potassium, the so-called electrolytes, and no sugar.

The electrolytes are critical to the function of every cell. In your body, in particular, the neurons, the nerve cells as I've talked about before on this podcast neurons nerve cells require adequate, sodium and potassium, as well as magnesium, in order to fire Action potentials, which are the electrical signals that allow neurons to do. Everything from generate focus and attention allow you to learn and generate neuromuscular connection and allow you to exercise or train or do any kind of skilled activity with a high degree of output. I take element about two or three times per day, typically once in the morning and again after or during my bout of exercise each day and sometimes an additional one. If I've sat in a hot sauna and sweat a lot or if the weather is very hot, if you'd like to try element, you can go to drink element. That's [lmnt.com](https://www.lmnt.com), Huberman to claim a free element sample pack with your purchase. Again, that's drink element, [lmnt.com](https://www.lmnt.com) Huberman, to claim a free sample pack.

Today's episode is also brought To Us by Helix sleep. Helix. Sleep makes mattresses and pillows that are the absolute highest quality. Now sleep is the foundation of mental health, physical health and performance. When we are sleeping well all of those things Excel and when we are not sleeping well, all of those things suffer now the surface that you sleep on. That is the mattress that you sleep on is critical and Helix understands that everybody has slightly different sleep needs. So if you were to go to the Helix site, which I invite you to do and take their brief two minute quiz, it will match your body type and sleep preferences to the perfect mattress for you. It will ask you questions. For instance, do you sleep on your back or your side or your stomach? Do you tend to run hot or cold during the night, or maybe you don't know the answers to those questions? I went and took the Sleep quiz at Helix and it matched me to the so-called dusk mattress dusk. I started sleeping on Dust mattress over a year ago and it's the best sleep that I've ever had. It's completely transformed the depth and duration and quality of my sleep in ways that make me feel far better during the daytime. If you're interested in upgrading your mattress, you can go to [helixsleep.com](https://www.helixsleep.com) Huberman, take their two-minute sleep, quiz and they'll match you to a customized, mattress and you'll, get up to 350 off any mattress order and two free pillows again, if interested go to [Helix sleep.com](https://www.helixsleep.com) Huberman for Up to 350 off and two free pillows, today's episode is also brought To Us by eight sleep. Eight sleep makes Smart mattress covers with cooling Heating and sleep tracking capacity. Now again, sleep is the foundation of mental health, physical health and performance, but what many people don't realize is that, in order to fall and stay asleep, your core body temperature has to drop by about one to three degrees. Conversely, in order to wake up each morning and feel refreshed your body, temperature actually has to increase by one to three degrees. Therefore, controlling the temperature of your sleeping environment is absolutely key with eight sleep, that's very easy to do depending on whether or not you typically run too cold or too hot during the night you can program your eight Sleep mattress

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00:06:58 Sleep Phases, Perfect Night's Sleep

Expanding again, that's livemomentous.com Huberman and now for my discussion with Dr Gina Poe, Dr Gino Poe, welcome. Thank you. I've really been looking forward to this conversation because I'm familiar with your work - and I know that many people are going to be excited to learn about your work as it relates to sleep as it relates to problem solving creativity, addiction and craving relapse. And a number of other important topics so to start things off, I would love for you to educate us a bit about this thing that we are all familiar with, and yet very few of us understand, which is sleep and if you would could you describe the Various phases of sleep that exist, what distinguish them and perhaps frame this within the context of what would a perfect night's sleep? Look like okay? How long would it last more or less, and what would the biology look like what? What is a perfect night's sleep? Oh yeah, that's a great question all right, so sleep is really different from wakefulness and, in fact, can't be replaced by any state of wakefulness that we've been able to come up with so far. Our brain chemistry is completely different and in the different stages of sleep which there are is non-rem and REM are the two major states of sleep and every animal we've studied so far seems to have both of those States anyway. Those two states are entirely different from one another too, and even within non-rem. There are three states stage, one which is what you slip into when you first falling asleep. It's dozing, there's kind of an interesting Rhythm that goes on in the brain. It's kind of a fast gamma Rhythm and then there's stage two, which is a really cool State. We sort of used to ignore sleep researchers because it was a transient State between wakefulness and the Deep stage, three slow way, sleep, which is the most impressively different and then, and between that and REM, sleep. So stage two I'll talk a

little bit more about and then the Deep slow way sleep state, which is when big, slow waves sweep through our brain, and now we realize that it cleans our brain. One of the things that those big slow waves do is cleans. Our brain and does other really important things to restore us um from a day of wakefulness and then REM, sleep which is the most popular because that's where we have the most active dreams and um. When you wake up someone out of REM, sleep they'll almost always report having dreams. Something really bizarre. That's called REM, sleep, rapid eye movement, sleep, so those are the four states of sleep of human sleep and we cycle through them every 90 minutes or so when we go to sleep, say: 10. 10, 30. 11 o'clock, our first REM, sleep period, comes about a hundred and five minutes after we fall asleep and lasts about 20 minutes. Actually, it comes about 95 minutes and last 10 or 15 minutes, and then we start over again and we have about five of those per night for a perfect night's sleep, four or five. Something like that. So A Perfect night's sleep is seven and a half eight hours. There was a really great study that put people in a semi-darkened room with nothing, but the bed for 12 hours every day for a month, and what people did initially is because, because we're in a sleep, deprived nation, is that they slept a lot more than usual. Like 10 or 11 hours of the 12, and then they leveled off after a week or two to about eight hours and 15 minutes of sleep, so you actually can't oversleep. I mean they had nothing else to do butt sleep and they would round off to on average, eight hours and 15 minutes a night and then to spend the rest of the

00:10:32 Can You Oversleep?

Time twiddling their thumbs, humming Tunes, interesting daydreaming. I want to get back to the Contour of a perfect night's sleep, but I'm intrigued by this idea that people can't oversleep I'm often asked whether or not we can get too much sleep and whether or not sleeping too long long excuse me can make us groggy. The next day is there anything to that um and how does one determine how long they should sleep right on average on average yeah? Well, that's interesting because different people need seem to need different amounts of sleep, but we don't really even know exactly what sleep is for. So what they need is you know kind of it's it's. You know Mercury murky um, so we do know a lot of things that sleep does now for us, but we don't know how long those things take. So how long we need to sleep is also just a big question mark, but some people don't feel rested until they've slept nine hours and some people don't feel rested after three or four and a half, but most people if they consistently deprive themselves of sleep so That they're only sleeping four four and a half hours a night build up a cognitive deficit that just builds up over time. The more nights

you have with sleep deprivation, the more cognitive deficit you have, and so you need sleep again to sleep more to recover. Now the question you had about um: can you over? Can you oversleep right? Can you sleep to the point where it's too much? You know that we I growing up um when I was in high school. My girlfriend's dad had this belief that no one should sleep in past 6 a.m, so he would wake all the there were two children in that home. He would wake up the kids in that house. He had to sing Against over sleeping regardless of when people went, went to sleep, and I always thought that was um, an interesting mentality, yeah um, that's not terrible. Actually, because what that will do is it'll put you make you sleepier the next night to get to bed on time, so it'll build up your homeostatic need if you wake up too early but um, so I don't think you can oversleep, but people who sleep a Lot like people who sleep over nine hours, it's probably indicative of some other problem, because, in fact, if you have a lot of different conditions, it will cause you to sleep a lot more, probably because what it does is it interferes with your efficient sleep. The efficiency of your sleep, so if you find yourself sleep being consistently nine hours plus every night, then you might want to consult a doctor about maybe what else it might be. It could be cancer, it could be sleep apnea that just affects a lot of people. It could be that your sleep is super inefficient because you're snoring a lot more than you know or you're waking up a lot more than you know every night. So you might want to sleep study just to see how your sleep is and then see what else might be, causing you to sleep so much, and that wouldn't be. If somebody is sleeping nine or ten hours. You know every once in a while. You mean, if they're, consistently sleeping for more than nine hours, they feel like they need it in order to function cognitively the next day. It might be that your sleep is just not efficient and you might want to look into why that that's the case interesting. Forgive me for the anecdote, but I can't resist years ago I went to an acupuncturist and um. He gave me these red pills, of which I don't know what they contain uh-oh, but I took them because he told me they would help with my sleep and I would fall asleep about 30 minutes after taking them, and I would have incred incredibly excuse me vivid Dreams and I'd wake up four or five hours after having gone to sleep feeling completely rested something that I've never really experienced interesting on a consistent basis. I want to do mass spec on these pills. I still have no idea what was in them whatsoever exactly some people have thought that perhaps they had GHB gamma hydroxybutyrate, which is by the way, an illegal drug. It can kill you, it's not a, not something you want to take um but anyway, if, if ever someone can figure out what the red pills were I'll be very um, and this is not a red pill of the of the other sort red pill. This is just the red sleep pills. Interesting, I mean it could have been even a placebo effect, because Placebo is extremely strong. So, although I I don't know, there was really something to these red pills

00:14:50 Sleep Cycles, Sleep Spindles, "Falling" Asleep, Dreams & Memories

So shout out to the acupuncturists and uh and the Eastern medicine um, but to return this I to this idea of the architecture of a perfect night's sleep. So you said um, we fall asleep. The first 90 minutes of sleep REM, sleep, rapid eye movement. Sleep will arrive at about 95 minutes in. Does that mean that the rest of that 90 minutes is consumed with slow wave sleep, yeah, non-rem, sleep, okay, and what about the Sleep where we are lightly asleep? And we might have a dream that has us somehow thinking about movement or that we jolt ourselves away, because that often happens early in the night. Yeah yeah. That's the first stage stage, one and stage two of sleep and stage: two sleep is really cool, because that has something called sleep, spindles and K complexes and what sleep spindles are are a little bit of activity. That's 10 to 15 Hertz in frequency. It's a conversation between the thalamus and the cortex, so the thalamus is the gateway to Consciousness and the neocortex. You know, processes all our cognition and um. So it's it's. These spindles they're called sleep spindles and if you wake up out of that state, you will often report a dream like a hallucination style dream. It won't be a long dream report like you, have out of REM sleep, but it will be some hallucination state enduring. While we're falling asleep one of the reasons we call it falling asleep is because in stage one and stage two our muscles are relaxing and if there's part of our brain, that's conscious enough to sort of recognize that relaxation will feel like we're falling and will jerk Awake so often that hallucination, it's called hypnagogic hallucination will feel like it'll include some falling aspect that will wake up out of that's really interesting to me. I've long felt that sensation of almost like dropping back into my head um, so much so that if I elevate my feet just slightly and I tilt my head back just slightly in order to go to sleep, I find that I fall asleep much faster interesting, but It does feel as if I'm going to fall, like almost gonna, do a backward somersault. I actually really like the the sensation and usually because it proceeds falling deeply yeah. That's really interesting. I'M somebody has to do a study of elevated feet and yeah. There'S a little bit on um body position and sleep and some of the washout that we'll talk about so early in the night um. You got these lighter stages of sleep, less rapid eye movement, sleep. What can we say about the dreams that occur during the say? First and second um, you know 90 minute cycles of sleep. Are they quite different than the patterns of sleep and dreaming that occur later in the night or toward morning? Well, okay, that's an interesting question. There'S a lot of facets to it. There is some evidence that the first four hours of sleep are very important for memory processing and in fact, if you've learned something new that day or have experienced a new sensory motor experience, then your early sleep dreams will incorporate that experience. Much more than the later sleep dreams later, as that memory gets Consolidated from the early structures, which are the

hippocampus deep in the temporal lobe to the cortex in a distributed fashion. That memory seems to move from that hippocampus to the cortex and also the dreams that incorporate that memory also move later in the night. So nobody knows why, but it does. There was a great study by siddarta Ribeiro who studied the consolidation of memories from the cortex from the hippocampus to the cortex in a rat across the period of a full day. Sleep because rats sleep in the daytime and he found that each subsequent REM sleep period, moved that memory, a from the hippocampus to the first first area, that projects to it and then the second area. And then the third area. And you can see the memory moving

00:19:01 Tool: Growth Hormone Release & Sleep

Um through the throughout the Sleep cool period, yeah very cool, so you have to read that study. So um there's a number of different hormones associated with the different stages of sleep. We know that melatonin is a hormone of nighttime of nighttime. That makes a sleepy um what about growth hormone release when does that occur during sleep, so growth hormone release happens all day, long and all night long, but the Deep, slow way sleep that you get. The very first sleep cycle is when you get a big bolus of growth, hormone release and in men and women equally, and if you miss that first deep, slow way sleep period, you also miss that big bolus of growth hormone release and you might get ultimately across The day, just as much overall growth hormone release, but endocrinologists will tell you that big boluses do different things than a little bit eeked out over time. So that is well. We know, there's also a big push to synthesize proteins. So that's when the protein synthesis part that builds memories, for example in our brain, happens in that first cycle of sleep. So you don't want to miss that, especially if you've learned something really big and needs needs more synaptic space to encode it. How would somebody miss that first 90 minutes driving themselves yeah? So so let's say I normally go to sleep at 10 pm and then from 10 to 11 30 would be this first phase of sleep and that's when the growth hormone, big bolus of growth hormone would be released. Does that mean that if I go to sleep instead at 11, 30 or midnight that I miss that first phase of sleep, why is it not the case that I get that first phase of sleep just simply starting later? It is a beautiful clock that we have in our body. That knows when things should happen, and it's every cell in our body has a clock and all those clocks are normally synchronized and the Circadian clocks are synchronized, and so our cells are ready to respond onto that growth hormone release at a particular time, and if we Miss it and it's a time in relation to melatonin also so if you miss it yeah you might get some growth hormone release, but it's occurring at a time when that your clock has already moved to the

next phase, and so it's it's just a clock thing. Yeah, I don't think we can overstate the importance of what you just described and to be honest, despite knowing a bit about the Sleep, research and circadian biology. This is the very first time that I've ever heard this that if you normally go to sleep at a particular time and growth hormone is released in that first phase of sleep that you can't simply initiate your sleep bout later and expect to capture that first phase Of sleep yeah, that's incredible and I think important and um, as many listeners are probably realizing, also highly actionable. So what this means is that we should have fairly consistent bedtimes in addition to fairly consistent, wait times. Is that right exactly and in fact one of the

00:22:05 Adolescence; Early Sleep, Alcohol & Sleep Spindles

Best markers of good neurological health when we get older, is consistent, bedtimes, wow, okay, um. I don't want to backtrack, but I did write down something that I think is important for me to resolve or for you to resolve. So I'm going to ask this um people that sleep, nine hours or more perhaps that reflecting an issue. Some underlying issue, perhaps is being a teenager or an adolescent and undergoing a stage of of development where there's a lot of bodily and brain growth. In exception to that, because, yes, I don't recall sleeping a ton when I was a teenager, I had a ton of energy, but I know a few teenagers and they sleep a lot yeah like they'll, just sleep and sleep and sleep and sleep: should we let them Sleep and sleep and sleep okay, I can sleep okay, so that's the one exception. What about just like babies? Okay, when you're developing something in your brain or the rest of your body. You really need sleep to help. Organize that I mean sleep is doing really hard work in organizing our brains and and making it develop right, and if we deprive ourselves of sleep we will actually also just I like, like. I said we have a daily clock. We also have a developmental clock and we can miss a developmental window if we don't let ourselves sleep extra like we need to what other things inhibit: growth, hormone release or other components of this first stage of sleep. In other words, if I go to sleep religiously, every night at 10 pm are there things that I perhaps do in the preceding hours or the preceding day like ingest, caffeine or alcohol, that can make that first stage of sleep less effective. Even if I'm going to sleep at the same time, alcohol definitely will do that because alcohol is a REM, sleep suppressant and it even suppresses some of that stage. Two transition to REM with those sleep spindles and those sleep spindles. We didn't talk about their function yet, but they're really important for moving memories to our cortex. It's a unique time when our hippocampus, the sort of like the ram of our brains, writes it to a hard disk and which is the cortex and there it's a unique time when

they're connected. So if you don't want to miss that you don't want to miss REM sleep when is also a part of the consolidation process and schema changing process and alcohol in there. You know before before we go to sleep, we'll do that until we've metabolized alcohol and put it out of our bodies, it will affect our sleep badly, so probably fair to say no ingestion of alcohol within the four to six hours preceding sleep, given the half-life or At all, or at all would be better, but I know some people refuse to go that way and maybe a little bit is okay. I don't know what the dose response is, but um there are studies out there. You can look at great yeah, so we're still in the first stage of sleep and I apologize for slowing us down. But it sounds like it's an

00:24:55 Middle Sleep States & REM, Schema, Waking at Night

Incredibly important first phase of sleep. What about the second and third 90 minute blocks of sleep? Is there anything that makes those um unique? What is their signature uh besides the fact that they come second and third in the night, there's more and more REM sleep? The later the night we get um there's also a change in hormones. You know the growth hormone and melatonin levels are starting to decline, but other hormones are picking up. So it is a really different stage that you also don't want to shortchange yourself on and I think that's the stage. Many studies are showing that those are the times in sleep when the most creativity can happen. That's when our dreams can incorporate and put together old and new things together into a new way and um and our schema are built during that time. So um yeah. We can change our minds best during those phases of sleep. Could you elaborate a little bit more on schema? No one, I don't think anyone on this podcast has ever discussed. Schema I'm a little bit familiar with schema from my courses on psychology, but it's been a while. So maybe you could just refresh your mind and everyone. Well, it's it's still a concept right, I think of schema as um like we have a schema of Christmas right. We we have all kinds of ideas that we sew together and call Christmas a holiday season in the northern hemisphere. It's cold. We have Santa Claus and reindeer and jingle bells, and even things that are false, that that we normally associate with Christmas presents family gathering when it is all of this stuff is sewn together until one there's a thread linking them all, and we can just give ourselves A list of words and um and none of them contain the word Christmas and then ask people later um, you know, give them another list of words and include the word Christmas and they'll say: oh yeah. That word was there because in their minds they brought up that word Christmas, because it's part of that whole schema. So that's what it's sort of a related, a lot of related Concepts. I guess when I think about it, sort of like on the desktop of

my computer um would scare some people, but it's just a ton of folders yeah, but each of the folder names means something very clear and specific to me. Right and inside of those folders are collections of things that make sense in terms of how they're batched is that kind of one way, exactly? No that's a great way to think of it and and when you're in REM sleep in the later parts of the night and that transition to REM, that's when your computer of your brain is opening folders and comparing documents. Seeing, if is there anything the same? These two documents look very much the same, but there's a little bit of difference and it can. It can link those conceptually so that that's probably one of the origins of creativity is finding things that are related, maybe just linked a little bit, and you can find that link and strengthen it. If it, you know, makes your schema interesting and different, very interesting. Um. Many people, including myself, tend to wake up, maybe once during the middle of the night to use the restroom, I've tried to drink less fluid before going to sleep I've. I've heard also that um the impulse to urinate - I forgive the topic, but a lot of people deal with this, so the impulse to urinate is also dictated by how quickly you drink fluid, not just the total volume. So I've switched to sipping fluids more slowly. For my last beverage of the day, which seems to help, but the point here is that I think a lot of people wake up once in the middle of the night oftentimes to use the restroom but oftentimes just around 3 A.M and might be up for a few minutes, hopefully not on their phone or viewing any Bright Light, which can cause more wakefulness but then go back to sleep. Is there any known detriment to this middle of the night waking or should we consider it a normal feature for some people's sleep architecture? I think we shouldn't worry about it. Actually, I think you know sleep is really incredibly well homeostatically regulated and so really don't worry about how much you're sleeping as long as you're, not intentionally depriving yourself of sleep by doing something really rewarding and exciting, because even that is stressful to your body and deprives you a lot of things we're talking about, so don't worry about it, um, it's absolutely normal to wake up, at least once in the middle of the night to go to the bathroom and as long as you can get back to sleep in a reasonable amount of Time, um, you know, or even if it takes you an hour, don't worry about it as long as you have a lifestyle that allows you to then make up that sleep either the next morning or the next night or going to bed a little earlier. So if I understand correctly, there's a little bit of asymmetry to sleep that catching that first phase of sleep, it's like you either get it or you don't, and you have to get it by going to sleep essentially the same time each night, maybe plus or minus 15 minutes or so yeah, but then, if I wake up in the middle of the night and go back to sleep, I cannot catch up, but I can gather all the sleep that I would have gotten had. I just slept the whole way through the night. Is that right, yeah, yeah, okay, yeah and, and we don't know actually the answer to whether or not the sleep in the middle between that early sleep and the late sleep is in fact different for another reason,

and whether depriving yourself of sleep from say one to 2 30 in the morning is bad in a different way. We don't know well, I suppose I am the experiment in that case, because I do tend to wake up once per night and I've sort of come to recognize it as part of my normal sleep architecture, I don't obsess over it. I do notice that when I go back to sleep and especially toward morning that my sleep

00:30:33 Deep Sleep, Dreams & Senses

Is incredibly deep, my dreams are incredibly Vivid. I don't always remember them, but what is unique, perhaps about the architecture of dreams and sleep in the let's say the last third of the night or this or the second half of the night right yeah. The second half of the night, we have longer REM, sleep periods and those are considered the deepest sleep. Even though slow wave sleep, big, slow wave is considered deep. It is deep yeah, they call slow, wave sleep, deep sleep and REM sleep rapid I mean, but now you're telling me that REM sleep is actually the deeper sleep. Okay, there needs to be a new nomenclature, sleep, researchers! No, no, please. The reason why you cause slow wave sleep deep sleep is because it's difficult to arouse people out of that state and when you do arouse them out of that state, they are most often confused and just want to go back into sleep and can go back pretty Easily, if you arouse someone out of REM, sleep they're more likely to report something that was really kind of almost like wakefulness. It was so vivid, but in fact, if you give someone and none threatening kind of stimulation, like somebody dropping keys or a ping, or something like that, instead of waking that same volume will wake someone up out of non-REM sleep, but out of REM, sleeping instead lengthen The amount of time or make it even more dense and your rapid eye movements more dense and often people will incorporate that sound into their dreams. So the body and brain are somehow conscious of the um of the sound, and I've heard also smells can even make it into our dreams and REM sleep, but that we it doesn't arouse us. It doesn't arouse us as often yeah interesting, and maybe one of the reasons why REM sleep is deeper is especially in adults and older people that deep slow wave sleep goes away. So it's not as deep. It's not as big the slow waves aren't as large, which is probably problematic, but we're not sure, and so then REM sleep. It becomes the deepest stage actually in children, it's kind of a toss-up because they it's really hard to wake them up. Out of that deep, slow wave sleep and in fact fire alarms, don't wake them up even really loud fire alarms out of that state of sleep. So that's why they're trying to change fire alarms so that, instead of something that the kids don't associate with anything like whatever they don't associate when it says their name or something else that may be less loud but

more Salient to them and will wake them up. I don't know having carried sleeping children in from the car. I don't know that I want children to start waking up from sleep, because that's one of the best things when you get home and the kids are asleep in the back seat. You can literally throw them over your shoulder gently of course, yes and put them to sleep in, and they are completely

00:33:22 AG1 (Athletic Greens)

out yeah completely wonderful it is wonderful one of Nature's gifts I'd like to take a quick break and acknowledge one of our sponsors athletic greens athletic greens now called ag1 is a vitamin mineral probiotic drink that covers all of your foundational nutritional needs I've been taking athletic greens since 2000 and 12 so I'm delighted that they're sponsoring the podcast the reason I started taking athletic greens and the reason I still take athletic greens once are usually twice a day is that it gets to be the probiotics that I need for gut health our gut is very important it's populated by gut microbiota that communicate with the brain the immune system and basically all the biological systems of our body to strongly impact our immediate and long-term health and those probiotics and athletic greens are optimal and vital for microbiotic health in addition athletic greens contains a number of adaptogens vitamins and minerals that make sure that all of my foundational nutritional needs are met and it tastes great if you'd like to try athletic greens you can go to athleticgreens.com Huberman and they'll give you five free travel packs that make it really easy to mix up athletic greens while you're on the road in the car on the plane Etc and they'll give you a year's supply of vitamin d3k2 again that's athleticgreens.com Huberman

00:34:37 Later Sleep, Paralysis, Sleepwalking, Sleep Talking

To get the five free travel packs and the year supply of vitamin D3 K2. So this enhanced volume or or proportion of rapid eye movement sleep in the second half of the night relates to more elaborate dreams. We are paralyzed during REM, sleep, correct! Yes, normally it's paralyzed and that's really good, because that's the time when we're actively dreaming storyline dreams and we could hurt ourselves - we're actually really cut off from the outside world. In terms of you know, responding to say this table or a window or a door, and so different from sleepwalking, which is out of slow wave sleep out of slowly sleep. That sleepwalking is a mixture between sleep and wakefulness, so you actually will respond to the

door. You can cook a full meal, drive your car, while you're in deep slowly sleep, it's scary, because you never know what you're going to do. You don't have voluntary voluntary control over it. You have no conscious control over it, but you can actually safely navigate some situations in sleepwalking and actually have a conversation, although it may not make much sense when you're sleep talking in REM, sleep you're, not processing the outside world and instead, when you're acting out your Dreams, you could be doing things like walking through a plate, glass window or falling off of you know down the stairs things like that. So you really want your muscles to be inactivated during REM, sleep. Otherwise, you will act out those dreams and really hurt yourself or your bed partner. What about sleep talking or talking in sleep um? I don't know how many relationships have um been saved by sleep talking, but I'm guessing a few have been destroyed and I'm guessing that um talking in sleep could have meaning or perhaps has no meaning just as dreams could have meaning or no meaning, as we recall Them yeah do not take sleep talking seriously, no matter what people say, it doesn't necessarily reflect truth, so it's not like you're being more truthful when you're sleep talking, you just saved a number of relationships. Um, I'm not directing this to anyone in particular, but I I guarantee you just

00:36:47 Alarm Clock & Grogginess; Sleep Trackers, Brain & Sleep

Did um noted um so as people start to approach morning or the time when they normally would wake up, I've heard that it's important to, if possible, complete one of these 90-minute Cycles prior to waking up. That is, if you set your alarm for halfway through one of these 90 minute cycles that come late in the night of sleep, that it can lead to um rather groggy patterns of waking um. So I'll just ask you directly: do you use a an alarm clock? I do not um, thankfully I'm in a line of work that doesn't require me normally to do anything at any particular time. I'D do it when I do it unless I have to catch a plane, and then I always set my alarm just in case well. As a fellow academic, I can tell you. There are plenty of punishing features about being an academic scientist that um that offset the fact that you don't have to use an alarm clock, but it is nice that you can often set your own schedule. So would you recommend that, if possible, that people not use an alarm clock yeah? Absolutely if you can just listen to your body and wake up when you need to wake up? That would be great um but um. One of the reasons why we have such a grogginess is called Sleep inertia when we wake up out of the wrong state, which is um deep, slow wave. Sleep is because I liken it to uh like a washing machine cycle. This 90-minute Cycles, like a washing machine cycle and and um the first part, is to add water right and then your clothes are soaking wet. You don't

want to open the washing machine and try and function put them on and wear them around, while they're soaking, wet and full of soap. So you have to wait until the cycle is through before you can well. Actually, let's put it in the dryer too, before you want to wear them so yeah you can function. It just takes a little while for those clothes that brain to dry out, so you can actually function well, um, but it's better to wait through the whole cycle. Is complete and so that's why you want to set that 90 90 minute alarm clock and again that's around 90 minutes, because the first stage of sleep, the first cycle of sleep, is actually a little longer more like 105 110 minutes, but then the second ones and Third ones they get sort of shorter and shorter, as the night goes on and in the last few Cycles, you're just doing the N2 REM sleep cycle, which takes less time, and if you wake up out of REM, sleep there's usually no problem. Cognitively you're good to go. Are you a fan of of sleep, trackers, uh sure, yeah yeah? Do you use one I have one on? I don't take. I don't. I don't live my life by them because they are the best ones. Right now are about 70 effective at staging your sleep, so 70, it's okay, it's okay, but um. Take it with a grain of salt is what I'm saying. Yeah I've tried various ones, and I compare the mattress based one to a. I actually wear it on my ankle instead of my wrist but um and I do find it informative, but a um, a colleague of mine at Stanford Ali Crum, who works on mindset and belief, effects. Um talk to me about a study they did where people often will buy us their sense of daytime wakefulness based on their sleep score more than their subjective score. In other words, if they were told they got a poor night's sleep, even if they got a great night's sleep in the in - and this was of course measured in the sleep lab. So they they're able to compare people report feeling more groggy and the opposite is also true that if it says 100 or 90 on your sleep score, then people go, I feel great, even though they might not have slept well. So this speaks to the. I don't want to say placebo effect, but the sort of belief effects that are woven in with a score yeah um. So so it seems to me that combining subjective and objective data is probably better, and I do believe that you should trust your own physiology and the way that your body is telling you to feel, because in fact, it used to be that people with insomnia weren't Were often not believed because you put them in a sleep lab and they look like they slept great and you wake them up in the morning they say. Oh, I didn't sleep very well at all, and that's because probably we we just came out with a paper that shows that subcortical structures can be in a completely different sleep State than cortical structures, which is what we measure in the sleep lab. What the cortex is doing so it might be that people who say I did not sleep all night long, even though the cortex is saying. Oh no, you had great sleep was because they're they're monitoring their subcortical hypothalamus hippocampus Thalamus other other structures that the sleep lab. Just can't access, unless you have depth electrodes, which nobody really wants right, because that requires holes in the skulls and wires yeah wow. So,

does that mean that the last 50 plus years of sleep science um it's potentially flawed in some way, because they're only recording from I guess this would be. The analogy would be it's like recording from the surface of the ocean as opposed to the depth of the ocean right and trying to ascertain the life moving down deep in there, brace yourselves uh colleagues at Stanford, sleep lab and elsewhere uh. But please just tell us, because I think scientists want to know the truth, yeah yeah, for nothing that you you want to know what the cortex is doing. I mean the cortex is really important for a lot of things, but it doesn't necessarily tell you what a lot of other really important parts of the brain are doing in terms of sleep and um, but there's hope because in fact it would be great. I think that's possible from the paper. If you look at it, it's in pnas this year that you could detect subtle changes in the cortical EEG. That might be able to tell you what the subcortical structures are doing. Things like the absolute power in that sleep, spindle band, that Sigma band would change if the hippocampus is in REM, sleep and the cortex is in that sleep, spindle, State and and vice versa. So there is some hope that we can gain from people with depth, electrodes or animals with depth electrodes that we could backwards machine, learn what the cortex might be able to tell us about subcritical structures from the cortical EEG so interesting. This is going to be a stimuli. Yeah stay tuned. It's going to be a stimulus for development of new

00:43:19 Early Slow Wave Sleep & "Washout", Normal Sleep Cycle & Night Owls

Technology which is always going to assist in scientific discovery, um there's one more thing. I wanted to ask about the architecture of the night's sleep um in terms of early part of the night. Earlier you mentioned the washout of debris and um the so-called lymphatic system. I think is what you're referring to. Could you tell us a little bit more about the washout that occurs in the brain during sleep? What what that is and what roles it's thought to serve and perhaps if there are any ways to ensure that it happens or to ensure that it doesn't happen, and obviously we want this to happen. Yeah yeah um all right great question. We talked about the circadian clock and how certain things happen at certain times. Well, one of the things that happens when we're awake and talking to each other is that there's a lot of plasticity, there's something that I'm learning from you today and you're learning from me and that changes our synapses and it changes the way our proteins are going To be folded and and changed during sleep, it unfolds, this process actually uses a lot of ATP the power um structure, the fuel of the brain and it unfolds also proteins, while we're doing this while we're using them, and so during that, first part of the night. When we first fall asleep in the first 20 minutes or so we're building that adenosine back into ATP, and that's probably why

power naps are called Power naps because we're actually rebuilding the power and then we're also cleaning out through the Deep slow waves of slow sleep. Cleaning out all those misfolded proteins unfolded, proteins and other things that get broken down and you know need to be rebuilt when we're asleep because of its use during wakefulness. So I liken that too. You know having a big party during wakefulness and you need all those partygoers to leave in order to do the cleanup, and so what I think the mechanism is - and this is still something to be tested - is actually slow waves themselves, which is bad news for us. As we get older and those slow waves get smaller and uh slowly, sleep goes away so um. So what happens when a neuron is firing? Is that it expands? The membrane expands a little bit becomes more translucent. That's how we know one of the ways. We know that neurons expand when they fire and so every action potential the membrane expands a little bit as sodium brings water into the cell and then when they're silent, they contract and so in during slow waves. The cool thing is that the reason why you can measure them is that all the neurons, at the same time, not all of them, but a good portion of them are firing at the same time and silent at the same time, and so you think about that. As contracting and expanding all at the same time, it's kind of like a bilge pump of the brain so that can pump out glia, are also really important for this um in terms of cleaning up debris and transferring it to where it needs to go so um. So I think of it actually as a bilge pump cleaning out our brain, interesting. I've heard about the glymphatic system and the lymphatic washout. I've never thought about the mechanical aspects of it before. I always thought that for some reason that now it's obvious to me, there had to be something mechanical, but only now that you've educated me about this. I thought that for some reason, the the cerebral spinal fluid just starts washing through, but here you're talking about literally an expansion and a contraction of the neurons in unison and pushing the fluid through cleaning out any misfolded proteins or debris that might occur. Yeah, on the basis of these metabolic pathways, and the consequence of that is to to what to leave the brain in a state of um, more pristine action for for the next day. Yeah is that right, yeah, you think of it again, like a party and if you don't clean up after that party, you try and hold another one. The next day it's going to get more clogged. You know it's people have a harder time, moving around and enjoying themselves, and if that builds up day after day, you know it's going to be cognition. That would be the partygoers moving around um becomes card yeah, and so this um builds pump that you describe is associated with the big slow waves of of um deep well of slow wave sleep yeah um. So this is going to occur more or less in the first third of the night. Is that right, that's right and um? Are there things that inhibit this process and are there things that facilitate this process? Yeah yeah connected inhibit; it's not to get it um, but right and here too uh. Sorry, it's in trouble um, but - and is this similar to the case with growth hormone? Where, if you go

to sleep later than you would normally you miss the washout yeah? It's not you, don't delay it. You miss, you missed the washer. That's right! That's right! So if you go to sleep at one or two in the morning, your sleep is still going to be dominated by N2 and REM. Sleep not by slow wave sleep. So you need to you need to get that first bit of sleep would a caveat, be if somebody normally goes to sleep at one or two a.m and wakes up at 10 A.M, that, if that's their normal sleep cycle, yeah um, that should be okay. It should be okay, um, you would probably want to do. Somebody would want to do a sleep study with people who do that normally and see, if also the Melatonin releases later and the corticosterone rise. That happens normally in the morning also happens later. So if everything shifted good, um, okay, yeah, there are a few studies. I've um come across that really do argue for the fact that waking up Circa Sunrise, that doesn't mean at Sunrise but within an hour or two, maybe three hours of sunrise and going to sleep within four hours after sunset or so um, is actually better for the Health of all human beings than is being a night owl and the night owl there's almost like a night owl Posse out there, especially on social media. They get very upset when you say that you should see morning sunlight that after 10 a.m, you kind of miss the boat um. They get very upset because I think there are about 20 or 30 percent of people, perhaps who um, who really feel like they function? Better staying up late and waking up late and they function much less well waking up early and going to bed early, but the data on health metrics suggests that sorry night owls that they are wrong. Yeah. Sorry me because I'm a night owl, oh boy, okay! Well then, I'm apologizing directly - and here I'm not a really early morning person, I'm kind of more typical if I wake up. Naturally, around 6 30 somewhere between 6 30 and 7 30 a.m, go to sleep somewhere between 10 and 11 p.m. These are averages um, but I do notice that when I force myself to get up a little earlier and go to sleep a little earlier, that my mood and alertness and just overall productivity is much higher and there could be other variables there too. Absolutely right. I'M a night owl I love staying up late at night. Doing you know, writing grants writing papers watching movies whatever it is. I love it, but I like you and like every human being on Earth, do better if I go to bed earlier and wake up earlier. So one good thing for night owls is to have a child because they will wake you up. Their circadian rhythms are so strong, they will wake up and even if you deprive them of sleep in the first half of the night, they will still wake up like clockwork because their circadian rhythms are so strong at 6am. And so what you've you haven't done. Anything good for your kid. You haven't moved their cycle to later and be more in line with yours. In fact, you've just sleep, deprived them and made them miss a window and made them cranky the next day and made your life more miserable, so go to bed soon after your kids go to bed and wake up with them. That's the way to do it right. The child alarm clock another reason to have children. Yes, I got a dog a puppy and then that became a dog

specifically well for many reasons. But one reason was: I wanted to be one of those early morning. Raj. You know 5 30 a.m every morning, but I ended up getting a bulldog that would literally sleep 16 hours. If he could, a nuclear bomb could go off and he wouldn't wake up. But what I started to learn was that Bulldogs actually have sleep apnea there. It's as far as I know, they're the only species that has a genetically um they're. Essentially, an inbred um sleep defect, yeah, and so I actually don't encourage people to get Bulldogs because it's kind of a cruel breed. They suffer a lot in that body that they're born into anyway um a dog can accomplish some some of this, but get that get the uh the breed of dog that is going to wake up early, so, in other words, don't get a bulldog or a Mastiff. Well, you know, interestingly, all all um, predatory animals like dogs and cats, us um, well, more dogs, cats and lions than us. Wills can sleep. You know 16 hours a day, ferrets are predatory, they fight a pet ferret yeah and I sadly, I also used to work on ferrets, publish a number of papers, delightful animals, yeah and great, because you can study development, it's really cool um, because they're born very altricial, Like we are with brains that are not very well developed, and so you can see what happens through development and how important these different phases of development really are. But yes, um yeah, maybe we're not as Predator as much Predators as we think, because in fact, we our sleep is somewhere between the prey and the Predators um in terms of the amount of sleep that we usually need a night. But those Predators can sleep 16 hours, um napping all day, long and and they're more crepuscular, perhaps like their prey arm, so Dawn and dusk, active yeah, Dawn and dusk, active um yeah, but anyway, yes, uh children and dogs, actually in. If there was a poll done by the national sleep Foundation to see what the number one thing is, that wakes people up at night and number two is going to the bathroom number. Three is children because um, you know you're when your children are young, but that only lasts a few years that they'll wake you up when they're babies um. But the number one thing is: pets and pets needing to go out. Um or cats. Wanting to curl up with you or whatever it is Pets needs will wake you up more in the middle of the night than anything else. Another reason to not get a nocturnal pet people who get hamsters pretty quickly, realize that they are nocturnal and they want to run on their wheel around yeah. You got to put them in the living room away from where you sleep. I vote fish tank folks, um freshwater fish tank. There are all sorts of reasons to not get a saltwater tank, freshwater fish tank or a child um. I appreciate that vote and I appreciate you mentioning ferrets and by the way, folks they are carnivores. They are not rodents and they are. They have very elaborate brain structures and they're, very smart um in the same family as the honey badgers and the other muscivores anyway. Well, I shouldn't uh geek out too much on

00:54:30 Locus Coeruleus, Learning & REM Sleep

On the mustolids, or else I'll, take the the remainder of all our time. I'D love for you to tell us about REM, sleep and the Sleep later in the night as it relates to dreams and emotionality, and this is probably um the appropriate time for you to introduce us to this incredible structure in the brain, which is the locus ceruleus. A difficult um structure to spell, but a beautiful, a beautifully named structure um I find Lucas release to be just fascinating and I know I you know a small fraction of what it does and I'm hoping you're going to educate me and and our audience about more About what it does and hopefully tell us a little bit about its relationship to epinephrine AKA, adrenaline yeah, I'm so glad you brought this up because I can totally geek out on the locus or list. Please do Locus, meaning spot or place and serverless meaning blue. So you could just call it the blue spot. That's the easiest. Every animal with a brain has a blue spot and um yeah, and I mean every other animal with the brain because of course, there are animals with nervous systems that are not centralized like jellyfish um, but anyway we're digressing there. So um, the locus to release is filled with neurons that have in them. Norepinephrine, which is the brain's version of epinephrine or adrenaline, is also called noradrenaline and what it does is it just like adrenaline and the rest of our bodies. It helps Primus to respond to our environment. So when Locus rulis, neurons, Fire and Fire in a burst, we can switch our attention and they will fire in a burst. If, for example, a loud noise happens in the middle of your concentrating on something, so you can it helps it fires and it helps you switch your attention to that thing and then learn quickly from it. So it's really important in a stress response. It helps us. Do a quick one, trial, learning and and then a tonic activity during the day when you're, just you know doing normal, going about your normal concentration kind of activity activities is really good for sustained attention it. It works with the cholinergic system of our basal forebrain, which is really important for learning and memory also to help us learn about things and put things together, but just Tonica level levels are signature of wakefulness and alertness. So too much is panic with a local surrealist activity. A burst is switching attention and then tonic levels are sustained constant attention and then, when we go to sleep, the locus cerealis slows and goes from about on average two Hertz to about one Hertz one cycle per second tonically. And then when we go into REM sleep. It's the only time when it shuts off completely, and it appears that that complete silence is really really important for a number of things, and the main thing that I think it's important for is the ability to erase and break down synapses that are no longer working For us, so they encode things that are false now or they are encoding things that we learned in the novelty encoding Pathways of our of our brain that have now been Consolidated to other Pathways, and so we need to Now erase them from the novelty

encoding pathway And that is really really important for being able to continue to learn things all of our lives so like erasing that REM um or that I don't know, what do you call those discs that you stick into computers, that'll, uh, hard drive, uh, no um, erasing your Thumb drive so that thumb drive is what you carry around all day long and then during sleep. You write that thumb drive to the cortex to the long-term memory structures and you need to refresh that thumb drive and that's what happens during REM sleep when the locus cerealis is off, because whenever it's on and neurodrenaline is there, it helps us to put things together. It helps us to learn and strengthen synapses, but it does not allow us to actually weaken synapses that are also a really important part for Life. Important part of lifelong learning, um yeah, there's so much more. I could say about that. Yeah Lucas Aurelia sounds fascinating, so it's connected to the basal forebrain cholinergic system, um the neurons in Locust ceruleus. If I'm not mistaken, release norepinephrine, perhaps epinephrine as well uh um. Well, no, the brain's version of epinephrine is norepinephrine um. The other thing it also uh the precursor to norepinephrine is dopamine, and so the source of dopamine in the hippocampus seems to be the locus cereals and it's still a mystery, is under what conditions. The Locust rules also releases dopamine, but it's really important when we're learning something new to also release dopamine or to at least activate the dopaminergic receptors in our hippocampus, so yeah so dopamine norepinephrine and then there's also galanin, which is important for releasing when we're stressed and It helps also without rapid learning. It works in concert with norepinephrine and in doing what it needs to do to strengthen synapses so that we learn really quickly. I I love um that there are multiple molecules involved, because that signals us to a principle, which is that, even if people can't remember all the names um that rarely in biology is something handled by just one. Molecular pathway. That redundancy is the rule yeah, because signaling attention to specific events is so important so that I'm going to use that as a just so story. I always say you know I wasn't consulted at the design phase, but it makes sense to me as to why redundancy would exist in this system absolutely and in fact, when we form hypotheses about the brain, we're always wrong, and the reason why we're always wrong is Because it's more complicated than we'd like to think and because in our brains, when we're forming hypotheses, it's we fail to account for all of the factors that are involved. You know the glia, the neuropeptides, the neurotransmitters, the physical structure of synapses, and so when I was going through grad school 35 years ago, uh we, the Dogma, was that every neuron contains one neurotransmitter and releases one neurotransmitter and you had excitatory neurotransmitters and inhibitory neurotransmitters and Neuromodulatory neurotransmitters, but that's as complicated as got and then we started talking about neuropeptides and people said: oh no, please don't don't complicate it and then we start talking about how neurons

contain both neuropeptides and neurotransmitters and maybe more than one neurotransmitter, maybe even hormones too. Even hormones - and oh Lord - you know it's just so complicated but got ta admit that's why it works right and every time the brain teaches us something new about itself that we didn't hypothesize. We say. Oh, of course, is that wouldn't work. If the way I hypothesized it with it, you know we actually need redundancy. We need all these systems to work together, so it's uh daunting sometimes, but it also ensures many many careers in science and Neuroscience in particular

01:01:46 Post-Traumatic Stress Disorder (PTSD), Locus Coeruleus & Sleep

So um note that aspiring scientists there's plenty of room uh for Discovery. Do you want me to talk about norepinephrine yeah? Yes, well, what I'd love? What I'd love for you to um tell us about! Is you know what role this lack of norepinephrine released during rapid eye movement? Sleep is thought to achieve, and maybe you could also review some of your work describing conditions under which norepinephrine invades, yeah, rapid eye movements, sleep and other patterns of sleep and how that can be detrimental yeah. So a lot of this is hypothetical, but based on a lot of good evidence that we're sewing together into the schema from which these hypotheses come. So a model schema from which the hypotheses come. But one thing that happens to people with post-traumatic stress disorder is that there is a lot of evidence that the locus cerealis doesn't stop firing in REM sleep so, whereas their levels of norepinephrine might be similar to people without PTSD during the day and even during the First part of the night during the wee hours of the morning and when you measure norepinephrine levels from metabolites in the blood or the cerebral spinal fluid, you see that people with PTSD it's during the wee hours of the morning when you have the most REM sleep That they have their neuropinephrine levels, differentiate most from those that don't have PTSD, and so that's evidence that the locus reality is not shutting down during REM. Sleep like it should other evidence is heart rate variability. When our Locus realist is firing, our heart rates are generally a little higher and they don't vary as much as they do when the locusceralis is not firing. So during slow wave, sleep normally have this big juicy variability in heart rate, with every breath in and breath out, because our neuroenergie levels or norepinephrine levels are lower during REM, sleep that goes away entirely and our heart rate is, is um, is dominated by parasympathetic, rather Than sympathetic activity, and also what our brain is driving, you know what we're dreaming about. For example, if We're Dreaming we're running, our heart rates will go up, but norepinephrine levels still should be low or off so people with PTSD that neuroenergies we're studying these in rats too. Is it true

that our Locus cells doesn't um shut off when we have post-traumatic stress disorder and the preliminary evidence is yes, it's true that it doesn't shut off. So what that would do is norepinephrine would act at synapses to prevent that weakening that you really need, for example, of novelty, encoding structures, and it keeps memories in that novelty encoding structure, even once it's Consolidated to the rest of the brain, so in the hippocampus, which is important for remembering things throughout our lives and and it's that thumb drive um, we we need it to be erased so that we can learn new things once it's been Consolidated to the the hard drive of our cortex, and so, if we're not able to do That we fill up that Ram um really quickly or that thumb drive really quickly and we're not able to learn new things. So, for example, after a trauma I talked about the locus responding in stressful situations. That's great it's very adaptive, but then you need it to stop once you've learned what you need to learn from it and you want to go to sleep, you need the locus for Less to calm down and during REM, sleep. You want it to stop because then, when you've Consolidated that traumatic memory to the cortex, you need to erase it from the novelty encoding structures, for example in the hippocampus, so that then, when you're in the context of safety, you can learn those new things. Those new contexts and um and stop responding to those same stimuli as though you're in that original situation. So if you're not able to erase that thumb drive, you will always feel like that trauma happened that same day like earlier that same day and respond as you would to a an early, a recent trauma which is with beating heart and all of that, so even Memories that are years past, if you're never able to downscale that novelty encoding structure and you purge it from that traumatic memory. It will

01:06:13 InsideTracker

stay fresh and new and then become maladaptive I'd like to just take a brief moment and thank one of our podcast sponsors which is inside tracker inside tracker is a personalized nutrition platform that analyzes data from your blood and DNA to help you better understand your body and help you reach your health goals I've long been a believer in getting regular blood work done for the simple reason that blood work is the only way that you can monitor the markers such as hormone markers lipids metabolic factors Etc the impact your immediate and long-term Health one major challenge with blood work however is that most of the time it does not come back with any information about what to do in order to move the values for hormones metabolic factors lipids Etc into the ranges that you want with inside tracker changing those values becomes very straightforward because it has a personalized dashboard that you can use to address

the nutrition-based behavior-based supplement-based approaches that you can use in order to move those values into the ranges that are optimal for you Your vitality and your longevity inside tracker now includes a measurement of APO lipoprotein B so-called APO B and they're all plan apob is a key marker of cardiovascular health and therefore there's extreme value to knowing your apob levels if you'd like to try inside tracker you can go to insidetracker.com Huberman to get 20 off any of inside

01:07:31 Locus Coeruleus, Trauma & Sleep, Antidepressants, Norepinephrine

Tracker's plans again that's inside tracker.com Huberman to get 20 off. What approaches are you aware of that? Can turn down the output of locus ceruleus during these phases of sleep and for that matter, what things can cause ramping up of locus cerules during this phase of sleep? We've had a couple: podcast episodes, solo episodes and with guests talking about trauma, we had Dr Paul Conte who's. A Stanford train, Harvard train um psychiatrist, who talked a lot about trauma, wrote an excellent book on trauma and um. Certainly, sleep was emphasized as a key thing. Like get enough sleep, but here you're saying even if somebody with trauma gets enough sleep if Locus ceruleus is hyperactive during sleep. Those traumas are going to persist and most of the trauma treatments that I'm aware of are everything ranging from cognitive. Behavioral therapy talk therapy drug therapy, EMDR hypnosis um. Nowadays, there's a lot of interest and attention on um clinical studies on exploring psychedelics, high-dose, psilocybin and MDMA. So it's a vast landscape, none of which, as far as I know, is really focused on sleep specifically no they're not, and they should be because actually psychedelics is a sleep-like state and um. It's a rem, sleep-like State, although of course there are some major differences. So yeah so much to talk about here so antidepressants um are often neuroenergetic or serotonergic reuptake inhibitors. So they leave norepinephrine actually out there in the synapses. And what that does? Is it inhibits REM, sleep and if you're able to get REM sleep, it would probably be REM sleep with some neuroenergetic activity. So actually I think anyway, I'm not a physician that antidepressants are counter-indicated. You don't want to take them. If you've experienced a trauma and you're experiencing PTSD, because if anything, it's going to make it worse or at least prevent the type of adaptive REM sleep that you really need in order to resolve those emotions and move on um. Is that statement specific to antidepressants that tickle, the noradrenergic pathway, so the the one that comes to mind is I can never pronounce it brupapron, which is uh. What I think brand name is Wellbutrin, it's a dopaminergic and noradrenergic Agonist, but so that's the net effect. As opposed to the Prozac Zoloft variety,

which are SSRIs - yes, yes, but SSRIs themselves - also are problematic because we didn't talk about it yet. But the dorsal raphe nucleus, which produces serotonin, which the specific serotonin specific serotonin reuptake inhibitors block from being reuptaken, leaves too much serotonin out there and what serotonin also is another neuroenergetic, I'm sorry, another neurotransmitter, that's down regulated during REM, sleep, that's specifically off during REM, sleep. And what serotonin does? Is it weights all of our cognition to being able to recognize novelty again, so it sort of waits our brain away from a sense of familiarity and toward novelty and um? It might be one reason why it's an effective antidepressant, because it makes the world feel fresh and new again right, but you, when you have too much you're, holding a novel, traumatic memory um in your novelty encoding structure too strongly already. You don't want to again weight things toward novelty. You need that absence of Serotonin also to help you get that sense of familiarity and to start erasing the novelty encoding structures. So you need both to be absent. It's really interesting. We hear a lot about serotonin and uh. It's not often discussed in terms of its features related to novelty enough. I think, and what you just described, accused me to something that Dr Paul Conti and others have said in terms of trauma, and here I'm paraphrasing. So my apologies to them for not getting this exactly right, that that an effective treatment for trauma does not erase the traumatic memory, but it causes a transition of what once was disturbing and invasive and maladaptive to eventually just become kind of a boring old story. That has kind of a fuzzy texture to it, as opposed to this kind of sharp high friction, texture that invades our thinking, um and obviously our sleeping states as well so um, again and uh. I appreciate the disclaimer or the caveats around. You know not being a clinician etc, but I do think that there's a lot of interest now in whether or not antidepressants are effective for trauma or not, and I think these these aspects of neuromodulation as they relate to um. Let's call it erasing traumas or changing the emotional load of traumas during sleep. Um is something important to take note. We also have a lot of clinicians that

01:12:29 Locus Coeruleus, Bedtime & Novelty, Estrogen & Trauma

Listen to this podcast, so they should also take note um, please. So if I want to reduce the amount of norepinephrine released from Locus ceruleus during rapid eye movement, sleep to eliminate the troubling or maybe even traumatic memories and allow late stages of sleep each night to have their maximum positive effect, is there anything that I can do? Besides, avoiding um, avoiding traumas, avoiding serotonergic or neuroadrenergic compounds well, I would also avoid anything just prior to going to sleep that might excite those systems so a lot

of novelty. A lot of you know, exciting um stress, inducing video games, try and enter sleep with as much calm as you can so maybe deep breathing exercises that's a beautiful way to calm your sympathetic. Fight-Or-Flight system is deep breathing and we haven't been able to test this with rats because we can't ask them to do a deep, breathing exercise. There might be a way we can do that, but I haven't found out or figured it out yet. But if there's a way you can make your sympathetic system nervous system, calm down before you go to sleep, might free for you, meditation or deep breathing exercises might be for some a warm bath or a comforting book. Nothing too exciting, but um. Also, nothing too boring. Perhaps um just something right in the middle, which makes you feel happy and calm as what you should do and if you instead go to sleep while you're, anxious or um you're hyped up, then your sleep could become maladaptive. Another thing that happens in rats that we have yet to know if it happens in women, is that female rats have three phases of their Ester cycle that their Locus realist doesn't seem to calm down during REM sleep as much, and we don't know why. But during the high estrogen phases of their estracycle, the locus shuts down just like it does in male rats, but in the other three phases it doesn't so um. One thing that might work and in fact there are a few studies that show it. It could work. Really well is um uh, giving women after a trauma event something that contains estrogen, because estrogen somehow is protective against PTSD, and they know that through retrospective studies, where they gave women an emergency room, either a pill with estrogen and or without, and those that had pill With estrogen in it were much less likely to get PTSD from that trauma as measured a year later than those that had the pill without so um. There'S some really good Studies by Bronwyn, Graham she's, out of Australia, to really hone in on how much estrogen do you need and also testosterone? Just so you know it gets converted to estrogen in the brain. So testosterone also can be protective because it gets converted to estrogen, but there's something about estrogen. That's really helpful and protective about that from from the high Locus cyrillus firing - and this is again preliminary data that we don't have full. We don't have all the answers yet and um. We are looking into it actively right now, but it's really important. The other thing about women is that we are two to four times more susceptible to anxiety-related mental health disorders, including post-traumatic stress disorder. So if we could figure out what's happening to the locus oralis during sleep in women, um that and then figure out a way to normalize that so the locus realist is silent when it needs to be silent, I think we could go a long way in

01:16:22 Sex Differences & Sleep

Helping women be more resilient to stress related disorders. What are some other um sex differences as they relate to sleep, yeah, yeah? That's a really good question: there have been very few studies, unfortunately, uh of women in sleep, um, women and estracycle or menstrual cycle, and sleep and um. But what we have found, which actually largely replicated a study in 1960 um, is that that women or females, rather at high estrogen High hormonal phases of their estracycle or menstrual cycle sleep a lot less, but that sleep is more efficient so that sleep is more dense. In those sleep spindles, which I haven't gone into, what they might do, except this connection between the hippocampus and cortex, but it's those sleep spindles, are more dense and more coherent across the brain areas. The Theta cycle, which is 5 to 10 Hertz in the hippocampus important for one year, learning and also important during REM. Sleep is also bigger and juicier during the high hormonal phases. So even though there's less sleep, it's more efficient and better um, but uh. So so all of that efficiency seems to be reduced in those other hormonal phases um. So, even though you might sleep a little more um, you might need more sleep. In fact, in order to accomplish the same thing that you can get with that short um, very efficient sleep of high hormonal phases very interesting, I think um. There is a growing Trend, at least among nih-funded grants to require that as they refer to it in the grants, a biological sex as a variable yeah, and then here we're talking about sex, the um the verb - although I'm sure there's studies about that too. But biological sex is a variable because there is a dearth of studies exploring sex differences in in most everything, there's all sorts of reasons for that, but, more importantly, that, fortunately, the trend is Shifting yeah um and even when you study males versus females a lot of People just say include females in their studies, but then don't track the estracycle or menstrual cycle and hormones have huge effects on our Behavior. I mean just think of it when he's had sex. You know before our hormones come in we're not interested in it and suddenly you know, that's kind of a main driver of behaviors hormones can definitely change who we are and what we do so we should be studying hormones, not just sex. I always say that puberty is perhaps the most massive transformation and rate of Aging that any of us go through in a short amount of time, an individual, their cognition changes, their

01:19:12 Tool: Non-Sleep Deep Rest (NSDR), Insomnia, Meditation, Prayer

Worldview changes and that's largely hormonal, driven and obviously neural architecture has changed too um. I'M very happy that you mentioned I'm trying to get into Commerce States prior to sleep and some ways to do that. I'M a big fan - and I've talked a lot before on this podcast about things like Yoga Nidra, which is a non-movement based practice, sometimes

called non-sleep depressed, where people actually take some time each day to practice how to go into a more parasympathetic, AKA relaxed State. Deliberately because it's a bit of a skill, yeah yeah, it's um and there's there's some good data, really mostly out of a laboratory in Scandinavia, showing huge increases in um Nigro, striatal dopamine, when people go basically engage in a practice of deliberate um non-movement and that the Brain actually enters states of a very shallow sleep, so sort of nap-ish. But the idea is to actually stay awake but motionless, and it does seem to restore a certain number of features of neurochemistry. But perhaps more importantly, it teaches people to to relax, which is something that most people are not very good at um but in any event, um and people who listen to this podcast have heard me say this over and over again. So I sound like a broken record, but this practice as a zero cost practice that doesn't require any pharmacology does seem to really enhance people's ability to fall asleep more quickly and to fall back asleep if they wake up in the middle of the night. So, in any event, another plug for nsdr Yoga Nidra. Well, I just also want to add to that. That's one of the reasons why insomnia is so Insidious is because when people feel like they haven't gotten enough sleep and aren't getting enough sleep and become anxious about getting enough sleep and then you're anxious before going to sleep like I'm, not going to fall asleep, it's Going to be 45 minutes in and then that's a positive feedback loop, so you need to bring break that Loop, say: okay, my body's going to get as much sleep as it needs. I needn't worry about it and then practice this relaxation to say: hey. It's all! Okay, it's going to be all right and and then concentrate on things that relax you um, whether it's concentrating or not, concentrating whatever it is. You mentioned um Yoga Nidra, and that reminded me of Transcendental Meditation, which is something that also hasn't been studied well or largely, because we can't ask non-human animals to do it. And so we don't know what's happening with our neurochemistry and our brain activity. In a deep and meaningful way, but one thing that has has been shown in those that can do it really well, is that that Theta activity that I said happens when you're learning something or when you're in REM, sleep it it's well established and and increases during The Transcendental Meditation, so it might be that some states of meditation could in some ways re, replace or mimic some functions of, for example, REM, sleep. But again we don't know if all the neurochemistry is right to do. For example, the thing that I was talking about, which is erasing the novelty encoding structures, the brain that needs an absence of norepinephrine and serotonin, which we don't know if that goes away with with Transcendental Meditation. We just don't know the answer to that. Yet yeah. The studies on on Yoga, Nidra and sleep replacement are kind of interesting um. It does seem to be the case that nothing can really replace sleep except sleep, but that if one is sleep deprived or is having trouble falling back asleep that these um things like - and I hear it's - I acknowledge this is essentially like Yoga

Nidra, but we now call it non-sleep deep, breast or nsdr, because oftentimes for names like Yoga Nidra act as a kind of a barrier for uh. What would otherwise be um people willing to try a practice? It sounds mystical. It sounds like flying carpets and you know it sounds like you have to go to esslin by the way esselyn's a beautiful place, but it sounds like you have to go there or live in the west coast to believe in this stuff. But it's simply not the case. These are practices that that are really just um self-directed relaxation as a practice that that allows people to get better and better at directing their brain States towards more relaxation, and most people have an asymmetry like, for instance, most people can force themselves to stay up later, But they have a hard time going to sleep earlier and that just speaks to the asymmetry - that's probably adaptive in survival, based that we can ramp ourselves up far more easily than we can tend to calm ourselves down yeah, and actually you know to appeal to other Christians, like me, prayer, can be a wonderful way to calm yourself down because through prayer you're giving your cares to God and saying you know, and then you are relaxed more relaxed. And I just want to say that, because the same reason that yoga might put some people off, it might put some people off um to to talk about prayer. But it's the same process of being able to relax and yeah and get outside our own experience. A little bit experience, yeah, um back out, get a world view that might actually also help us to relax um. Well, you might be surprised at how many um clinicians and scientists who've come on. This podcast have mentioned things like prayer from various perspectives: Christianity, Judaism, Muslim traditions and others that um as a as a parallel to all of these things - and I think what it speaks to is the fact that ultimately, the biological architectures that we're all contending with are going to be identical, right and so different ways to tap into them and ones that are um congruent with people's beliefs, I think is - are great yeah um yeah, because anything non-congruent with your beliefs is also stressful, right and feels forced, and that's why you know this idea of calling it non-sleep deep rest in addition to Yoga Nidra was not to detract from the naming or the history around Yoga Nidra, but I was finding that it was a barrier you know likewise. Um you're gon na need your attempts to include things like intentions, whereas nsdr scripts, and by the way we will provide links to some nsdr and Yoga Nidra scripts. But nsdr has no intentions. It's simply a body scan deep relaxation based. So it's sort of the scientific version of all of this stuff and actually we study it in the laboratory and and some of the brain states that people go into, but that's a discussion for another time. This is hard. My mother used to tell me when I said well, we could play. I can't go to sleep, she'd say well, you know start with your toes and relax, so you would clench your muscles around your toes and relax them and do that all the way from your toes all the way to your head - and I don't know where she got this, it might have been her own common sense or she might have gotten it from this uh NP NPR show it's called the mind, can keep you well, she at least

to listen to, but that's another intentional relaxation that focuses on the body um rather than on your own mental processes, but I do a little bit of work with the military and um there's a method within certain communities of Special Operations in the US military where, if they can't sleep or they're having challenges sleeping, they will deliberately try and relax their facial muscles, in particular, like sort of drape, the facial muscles and use long or exhale emphasized breathing does seem to increase the probability of transitioning back into sleep and those are hallmarks of Yoga, Nidra, non-sleep, deep rest body scans and, and so I think, all of these things converge on on a common theme, you know, as a neurobiologist, we can say all of the things that we are describing certainly move the needle away from Locus ceruleus activation, and we haven't done the experiment to really look at that. But it seems all these things are counter to noradrenaline release. Another one is yawning self is with that kind of sort of tensing of all the muscles in your face and then relaxing them. So it might be why we on we don't know why we yawn yet but um, it might also have. It would be really great. Actually animals. Yawn too, you know my Bulldog was a was a Perpetual if he wasn't sleeping, he was yawning and it would be interesting to see what yawning does to the Lucas realist. Does that also come and switch local circles activity, because it's an interesting that facial nerve, like trigeminal nerve, you know the through the vagus, connects um indirectly to the locus aurelis and has a powerful effect on that interesting uh common. I think friend of ours and direct colleague, viewers, uh Jack Feldman, was a guest on this podcast telling us about all the amazing structures. He and others have discovered in the in respiration and breathing. Yeah sounds like we have a collaboration

01:27:42 Sleep Spindles, Learning & Creativity, P Waves & Dreaming

Brewing here, the three of us should should definitely carry out I'd love for you to share with us a little bit more about these spindles that have come up a few times, and I don't know if it's relevant to this. So if it's not, let's separate it out, but I'd love for you to tell us a little bit about the role of sleep in problem, solving and creativity and if spindles are involved and I'll. Consider myself lucky for batching them in the same question and if they're not involved, simply feel free to separate them out. I think they could be involved and the reason why I think that could be involved, because we now know a lot more about spindles. First of all, the first thing that we knew first of all, we ignored them. Then we thought they had something to do with keeping us asleep, and that was their function is when an external stimulus came. They would keep us asleep because they would arise. But now we know that the density of our sleep spindles, the number that we produce per minute, is well correlated with our

intelligence in the first place and that no matter what your intelligence is and no matter what your sleep spindle density is, if you learn something During the day and increase your sleep, spindle density, it's really almost perfectly correlated with our ability to consolidate that information and incorporate it into the schema that we already have in our brain. So if you try and learn something new, even if your sleep, spindle density at Baseline, is great, if you don't increase your sleep spindles that night you're, not gon na, you know, use sleep to really incorporate it. Interestingly, sleep spindles are poor in those with schizophrenia. It's one of the characteristic signatures of sleep is that sleep spindles are very few and far between which might mean that um, that people with schizophrenia might not be able to incorporate new information into already existing schema and instead, it sort of Flaps in the breeze out There and can be accessed erroneously at times when you, you know, you don't want it to be involved so um, I digress, so sleep, spindles and creativity. So one of the things we now know through some great Studies by Julie, seat and Anita luthy, is that sleep spindles are accompanied by an incredible plasticity out in the distal dendrites, the listening branches of our neurons, that listen to other cortical areas. So there are proximal dendrites in our neurons that listen to the external world and are conducted through the thalamus, and then there are distal dendrites which listen to an internal kind of you know, conversation that's having happening in our brains. It's kind of you know our internal State really and during sleep spindles. That's when those distal dendrites are able to best learn from other cortical areas and from the hippocampus. It is during sleep spindles of the hippocampus and the cortex are best connected and when that class, incredible plasticity can happen. When I talk about schema, that's a cortical cortical thing: that's when you know the image of Santa Claus and presence you know comes together. It's not through some external thing, once we learn those things together, it's our cortex that that encodes that and brings those images back up together and that during sleep spindles, when that's happening when that there's big surges of calcium into those distal dendrites and where plasticity happens In in just huge amounts, during that sleep, spindle stage of sleep, which is N2 stage, there's also some another excitatory event that comes all the way from the brain stem and projects everywhere in our cortex, which is called pgo waves. That's P for pons G for ingeniculate nucleus of the thalamus, which is where they're first discovered an O for occipital area, which is our visual area, which is again where they're first discovered. But in fact it's now been shown that pgo waves, which we should generalize to p waves because they come from the ponds and go to the thalamus, and then the cortex happens all over the brains. And that is where glutamate, which is a major excitatory neurotransmitter involved in learning and plasticity, is being released in big amounts, also in those distal dendrites. So p, waves and spindles work together to cause plasticity, and so our schema together, which could be the origins for

insight and creativity. Now, when pgo waves or p waves, or first discovered, it was thought to be random, because this small area that generates p waves all over the brain, you know projects all the all over the thalamus and causes p waves all over and you don't measure p waves. All over the brain at the same time, in fact it's just seems sporadic and random. So that's, probably and p waves are also happening even more during REM, sleep, rapid eye movement, sleep. So, that's probably that's why people think that REM dreams are so Random is because these p waves are random and they could generate dreams because they're, an internal source of excitation. That kind of replaces the outside world during our dream state, and so these p waves, if they are random, could could function, could be the underlying reason why REM sleep dreams are random, and it might also be why creativity can happen. There is because we're randomly activating co-activating different things in our brain that we can then sew together, but it might not be as random as we think so. That's a caveat there. I just learned a lot from you because I I teach brain stem to medical students and I talk about the pawns and the pawns like this dense collection of all these different nuclei involved in a bunch of different things. And it's close by a bunch of interesting things and it's still kind of a mysterious brain area. But when I learned about pgo waves, I thought pawns geniculate occipital, because occipital is most commonly associated with visual cortex. I thought it was the origin of the visual component of dreams. It probably is I'm very happy to learn that they should be called p waves, because they include lots of different areas of the brain, and it makes really good sense to me why the kind of pseudo-randomness of Dreams, especially these late night and early morning, um later In sleep I should say, and early morning, dreams seem to be cobbled together from kind of disparate experiences. I mean you walk through a door and suddenly it's a completely different context and Landscape. Yes, um beautiful yeah. I I like this idea a lot. It makes intuitive sense, it makes biological sense. It also gives me something to talk about to the medical students next quarter. When I talk about pawns - and you want to talk about where in the pawns it's right below the locus surlist, it's called the sub surrealists they're glutamatergic. It's also called sld sublateral dorsal nucleus. So I love it so um note to any aspiring neurobiologist there's a a vast landscape of yet to be undiscovered structure and functions in the pond. Do you want to work on something that is sure to reveal something novel work on the palms, because it's in every textbook, it's a clinically, very important structure, um, sadly, gliomas can and another cancers of the brain can sometimes can often

01:34:51 Lucid Dreams, Reoccurring Dreams, Trauma

Surface in the in the ponds, but but we still know very little about it. Um I read a paper this last year or - and I think it was covered in a bit of popular press - that during rapid eye movement, sleep people can solve problems or respond to external stimuli like, for instance, they would give them math problems, they'd whisper in their Ear, while they were in REM, sleep, you know, what's two plus two and people would say, even though they were paralyzed, apparently they could still move their mouth because they'd say four or something like that or they'd say you know. What'S your name and people could respond and so that in REM sleep, perhaps people um, some elements of cognition are still active. I'M glad you brought that out. What do you think and I don't know the authors of that study and um and uh listen. If Ever I say something wrong, it's great on this podcast, because someone will tell us in the YouTube comments it's one of the great uses of YouTube comments, but I'd love to know your thoughts on that study I mean: is that just kind of a a an Odd feature that or does this have meaning, should we actually care about this result, there's no just about it. It's really actually intriguing and interesting and might relate to this paper that I talked about where we, where we said different areas of the brain, can be in different states. At the same same time, so lucid dreaming is another thing. We can't ask animals to do or can't ask them if they've done it but um. We can certainly ask humans to do it and some people can do it really well, and it would be really interesting to see in those people who could lucid dream really well, whether they spend more or less time in this asymmetrical state, where one area of the Brain is in one state and another area. The brain is in another, and it might be that those people can respond to questions during REM. Sleep best are those that have the most asymmetry or or dissimilarity or dissociation between subcortical and cortical structures, or it might be that they're, the ones with the most symmetry we don't know um. I do worry a little bit about lucid dreamy, because people are it's a fad. People are really excited about it and to be able to remember one's dreams is fun, often unless they're nightmares, and but it's really interesting or to be able to direct one's dreams if they are a nightmare. Is these really wonderful power to have and to be able to redirect a nightmare that has been repeated to something else and then kick yourself out of that repetitive nightmare is really nice, but um. I worry a little bit about because we know so little about. What'S actually going on in the brain, and if this lucid dreaming state is preventing us from, for example, from the locus realist from calming down or the serotonergic system from silencing like it should, and maybe what we're doing during this state is yeah. We'Re activating the learning and memory structures, but in a way, that's maladaptive in terms of the Erasure that we need to do so. Maybe one of the reasons why most people don't remember most of their dreams is for good reason. Your hippocampus is in a state where it's not writing new memories. In fact, writing out it's the memories it learned during the day to the cortex and it's immune from incoming new

information, so um, so maybe lucid dreaming is bad because you're you're activating the hippocampus in a way, that's writing new memories, and it might be really maladaptive For things like you know, PTSD, on the other hand, let me just argue myself right out of this when I used to have a repeated nightmare when I was a kid my mother was so wise would tell me well listen just next time. You're in that dream, you know, say: hey I'm in a dream and then change something about it. So she and I rehearsed what the horrible dream that it was. It was a big monster. You know running after me and my legs were like mud and I couldn't run away and it was just terrifying, and that was a dream I would have you know time and time again she said okay, next time. What are you gon na do in that? Monster? Comes after you laugh, so I'm gon na run away. No, you that's what you do every time and it's always the same outcome you can't run. So let's do something different like what what could you do? That's different, so I came up with I'll. I could turn around and punch it in the nose, yeah, that's great and so the next time I had that dream. I did recognize this is that same old dream, which means that there's part of my brain - that's conscious enough to know that this that I'm in a dreaming State and then I didn't, have the courage in my dream, because I was still terrified to punch. You know or touch the monster in any way, but I did have the courage to turn around and look at in the eye and say no. That was enough. I said no, and that was enough to knock me out of that Rhett of that dream, so that I never had it again. I never had that same dream again and in fact it gave me peace about dreaming, because I knew that if ever there was a nightmare that was just too scary. I could probably do something to change it and knock myself out of it. So, even though I don't recommend lucid dreaming on a normal day-to-day basis, if it's enough that can knock you out of a rut, one thing that happens with people with PTSD is they have the same repeated horrible nightmare, which is often a reliving of the day's trauma That that they had so maybe lucid dreaming can be used on occasion to be a powerful tool because there's so much plasticity that happens during REM sleep to knock you out of that ret of reliving that event and and just change it. You know, and you could probably practice, that during wakefulness um rehearse the event that happened, that was so traumatic and then just introduce a new element. Like you know, now I'm safe now you know the sound that was associated with that really traumatic thing. I should now associate with something else and next time I have that dream, I'm going to change it so that sound is now this new thing that it should be associated with safety, and that might be enough - maybe I hope, um to knock you out of that Repeated Nightmare and maybe even start you on the path to recovery, because if you can calm down about those nightmare stads of sleep, then maybe your Loca cyrillus, which is involved in stress, can also relax and you can do the Erasure parts that need to be done. I love it, I seem to recall a paper and I'll have to find the reference and and um send it to you. We will

also put in the show note captions that described a protocol that essentially matches this um uh idea and well. I think what they had people do is either cue themselves to a particular smell or tone in wakefulness, then, to try and recall a recurring nightmare yeah then, during the night's sleep they have the tone playing in the background, which would then cue them to the wakeful State they're still asleep mind you, but in the pseudo, Lucid or Lucid State, and then try and change some variable as you're describing some either look the the um predator in the eyes or do something different yeah and then in the waking State. Take a little bit of time to try and script out a different um narrative altogether, and it took several nights as I recall or more, but that they were able to escape this recurring nightmare. It was like a week or something yeah, so you're familiar with this guy. It's a beautiful study, I loved it yeah. We will put a reference to that. I um need to revisit that site. What'S pretty recent, but I need to dive into it again because I think I I didn't go as deep into it as I. I should have no no, but the one thing that you, you said many right things, but one of the things you said is that they were able to cue the dreamer um when they knew when they were going to REM, sleep, and then they played the sound Or had the odor now, when you're, normally asleep alone in your bed, you're not going to be able to cue yourself, but it might be that rehearsal enough before you go to sleep. Is enough to you know, help cue you to that repeated nightmare, remembering what the nightmare is and then figuring out how to cue yourself to do something different for years I had the same recurring nightmare over and over and over again, and it was so Salient and So clear and I'm not going to share what it is, because it's um it's not that it's that disturbing it was just. I think it was the emotional load of it and just how Salient certain features were like one person in um who's, a real life person had a particular um clothing, yeah on and it's like, and that just served as this cue and yeah. I don't know if I ever did any direct work to try and deal with it, but now it almost seems silly to describe it. Oh yeah, well, dreams are usually silly to describe. It was a pretty violent Dreams. Yeah and your emotional system is so geared up during REM, sleep, which is another thing we could talk about yeah, please um, I would love to yeah so Locus. Aurelius has ideally suppressed, so we can't release norepinephrine. We can't act out our dreams um this uh during these very emotionally Laden, um thoughts and and storylines during sleep. This almost like, starts to sound like a little bit of a built-in um, while sleeping trauma therapy, because most trauma therapies involve trying to get people into states of um counter to what most people think you actually want to get close to the trauma. In terms of the narrative but try and suppress the emotional activity of it or - and I guess that's - the motivation for ketamine-based therapies for trauma, or I've also heard - and this is still perplexing to me - that other waking based trauma therapies involve taking people the other way. Making it very cathartic take them to the peak of the emotional

01:44:11 Trauma Recovery, Locus Coeruleus & Norepinephrine, REM Sleep

Response but then allow that to finally cycle down into a more relaxed response. So please um, if there's anything about Locus, ceruleus and and dreams, and that can help people basically extinguish traumas or traumatic features to to real life events. And we definitely want to know about that yeah yeah. Well, I think one of the things that people thought might help after a trauma like a school shooting or whatever you know. Car accident is to talk about it and in, but in fact that ended up being counterproductive, and I think one of the reasons why it was counterproductive is because it didn't take them back down um. It brought them up and continued to reactivate the emotions of it. But then didn't you know, emphasize the safety effect that it's over um or help them work through how they might avoid it again in the future to calm the sympathetic nervous system down again before they went to sleep, and - and none of these studies has sleep ever been considered, but to me that's, the key part is bringing down your sympathetic nerve system before you go to sleep so that your sleep can be adaptive. Your Locus realist can shut off like it normally does, or should do and then able to erase the novelty of it. The other thing that um I just mentioned a minute ago, was that the emotion system is highly activated in REM, sleep and that's definitely true, and that might seem counterproductive in terms of you know the nightmares and and how to help REM. Sleep be a therapeutic thing. Rather than a um than a in reinforcing the emotionality of the trauma - and I think the key to that again is the absence of norepinephrine. So, even though the emotional system is in high gear, without norepinephrine, you can actually divorce those highly activated emotions from the cognitive parts of the memory that you have just written out in that NT stage of sleep when the sleep spindles are going so um, so you've just now consolidated the information that you'll need to survive and to you know to make that adaptive and now you need to divorce from that schema and from that semantic parts of memory. The emotional part, because whenever you remember something is fine, if you remember them being emotional at the time, but you don't want to bring back and so into that memory all of the same emotional systems. You don't want to bring back. You know the heart rate, changes and the sweating, and and all of that you want to be able to remember all the parts of it and even remember that you were traumatized and that you did cry and that you did have you know your heart was racing, But when you're talking about it years later, you don't want to have to relive all that. Otherwise, who who would ever want to recall a dramatic memory because you're, basically putting yourself through the same trauma, which is what people with PTSD, have they don't want to recall? This traumatic memory, because

it's reliving it like it's just happening again. So that's what we're thinking is that um, the emotional parts are no longer are not able to be divorced because the norepinephrine system is not downscaled during REM, sleep and so that REM sleep serves to. Instead reinforce and in fact amplify the emotions, because your your emotional system is up, look surilis, says Hi re-sewing in every night, the emotionality of those memories and with the memory itself um told us a lot about Locus, Aurelius and norepinephrine from Locus cerules. Is there any role for um, norepinephrine, epinephrine and cortisol released from the adrenals? My understanding is that norepinephrine and epinephrine will not cross the blood-brain barrier, which is probably why we have a brain-based neuroenergetic system, yeah Locus ceruleus and other and other neurons. Actually, that's a question. I should ask you: are there other sites in the brain where norepinephrine is released from or is it just Locus, cerules um? So there are, but it just occurred to me that um, in some cases like with raphae, there are other sources of serotonergic Drive in the brain. But raphae is like the means. Yeah, that's the one that goes to the cortex and and the locus roles is also the one that goes to the cortex. But there are other adrenergic sources, some that from the brain stem that descend and help us to ignore pain, for example, um. When we're stressed and needing to run away from the tiger right, we don't want to be thinking. Oh my ankle hurts you know you want to just be able to ignore it and go do what you need to do so um yeah. So there are lots of other neuroenergetic nuclei, but the local sterility is the main one that projects all over the brain. The actually the only place that doesn't project is the dorsal striatum. You talked about ventral, striatum and addiction. The dorsal stratum is the only place. The locus Rose doesn't project to and that's involved in, and procedural learning motor learning. The kinds of learning that take over when you're hippocampus, for example, is compromised. Bilateral. If you don't have good hippocampus, you can still do procedural learning and do and it's great it's a redundant system and so um. If your Locus cerealis is not working, if you don't have it anymore, you can still do if you, if you don't, have a good hippocampus, you can still do learning through this dorsal stratum structure, so it might be for those kinds of learning functions: sleep deprivation, where You never let the locus really stop. Firing is okay, because it doesn't have any receptors for norepinephrine anyway, so yeah, and what about bodily um like adrenals, yeah um, you know, I I often remind people there's no such thing as adrenal burnout per se. That adrenals don't actually burn out um, but some people have adrenal insufficiency syndrome. Other people have adrenals that are just chronically cranking out, epinephrine, norepinephrine and cortisol at the wrong times in particular, yeah yeah, so that those are great questions and I think the answers to them have yet to be discovered. The connections between our periphery and our central nervous system, but we know that there are beautiful connections and it's untapped source of being able to

manipulate our brains is to work through our bodies, and so our adrenals do great things. They constrict our blood vessels causing higher blood pressure which help blood rush out to all the extremities that need blood um. You know our muscles, for example, for running away from the lion um or the Tiger, or meeting a grant deadline or catching a train or catching a train. Yeah the adrenals help our hearts bump faster. Our muscles get profused with the blood it needs. It diverts blood and everything away from our parasympathetic system, which is rest and digest. We don't really need to digest that croissant when we're running for a train. We can do that later um. So it's doing really important things. What we don't know because it doesn't cross the blood-brain barrier, is how that affects the brain and whether our, if we can independently activate our adrenals um when a time when our brain thinks that we should be fine and calm and asleep. How our brain detects. That and is it a feedback through our heart is racing, and then our brainstem says what's going on. My heart is racing and then wakes us up, and then our hearts are racing together with our brain racing. We just don't know the answers to these questions. Yet there are some good good studies, old studies, but we need a lot more. I will another nod to the

01:52:15 Opiates, Addiction, Relapse & Sleep

Fact that there's lots of great work ongoing and still to do I'd love for you to tell us about some of the work that you're doing more recently on the relationship between sleep and opiate, use, withdrawal, relapse and um and craving just addiction generally uh. I get a lot of questions about people trying to come off benzodiazepines or people's challenges with benzodiazepine and other types of addiction, um yeah. What? What is the role of sleep in addiction and recovery from addiction and opiates, in particular yeah? This is a very young area and in fact my laboratory has just started. I have a graduate student who's been in my lab for just one year. She'S done amazing work already, but completely groundbreaking work and what she has discovered already. We don't have the paper out yet, but we're working on it is that when animals withdraw from opiates - and this has been sort of replicated in other ways with other types of things, our sleep is Disturbed, our sleep is terribly Disturbed and the amount of sleep disturbance Predicts relapse behaviors and you might think well course you're going to relapse. If you can't sleep because opiates calm you down well, one of the reasons why opiates calm you down is because the locus cerealis again loose fat is covered with opiate receptors and that are normally really responsive to our endogenous opiates, um and so what? What happens when we're pleased, for example, or laughing or whatever and Dodges opiates um activate those receptors in the locus rules and calm it down it actually

suppresses Locus activity makes us happy and relaxed. One of the things reasons why opiates are so addictive is because it also calms us down and makes us relaxed, but the problem with exogenous opiates is that they really strongly bind these receptors on our Locus cerillias. And if you take an exogenous opiates again and again, like you're recovering from surgery, for example, take these pain medications is that our Locus really struggles to do what it's supposed to do, which is keep us awake and learning and concentrating on things. So it will down. Regulate it will internalize these receptors that are normally only occupied by endogenous opiates, and, and it will do this, it will change our genes that are associated with producing these receptors, so you actually have very many fewer receptors. So the locus rules, at least during wakefulness, can fire and help us to do these things like learn about our environment, and so, if you long term reduce the number of receptors out there, then when you withdraw the exogenous opiates, it's not enough of your endogenous opiates To to be able to reoccupy those few receptors that are there and our local spirulis has nothing to calm it down, anymore, no pacifier and it just fires and fires and fires, and that phasic and tonic High activity stresses us out, because it's normally associated with stress And so any exogenous stressor that adds to that and also activates her Locus roles, there's nothing to calm it down again, and so it just keeps firing. It disturbs our sleep and that's why maybe sleep disturbance is a an indicator of a hyperactive Locus, cerillias and um and such a good predictor of relapsed behaviors, because nobody likes to live in that high stress state and they'll do anything to get back to normal. So the problem with with um taking these drugs is that it leaves you excited and or sorry excited, relaxed and happy, but then, when you come off of it you're worse than whether anywhere at Baseline, you take it again um. It only brings you up this far because you have fewer receptors when you come off it you're down even more depressed and and anxious and are depressed as a word I use Loosely and that's not that's not what I certainly central nervous system depression. I mean sleepier less motivated, lower mood. Yeah I mean our local surrealis is actually it's a it's in the anxiety kind of depression. Actually, the anxiety related depression, so um yeah, so we don't know yet what and there's some good research going on right now? What could restore our own endogenous receptors so that our own doogenous opiates can properly calm or Locus once that they have been tamped down by exogenous opiates, but that would be really one way that you can access the sleep disturbance. So we talked about sleep and the importance of sleep in terms of learning and memory, the importance of the structure of the 90-minute cycle. For all of that. So you can imagine. If your sleep is disturbed by too much Locos activity, then the the structure and the function of those sleep spindles and that Theta during REM, sleep and the and the lack of norepinephrine all of those structures. All those functions for for learning something new like a new behavior that doesn't involve the drugs becomes

compromised, and so that's something that Tanya Iugos in collaboration with Pamela Kennedy at UCLA that we're looking at how is learning and memory affected by the sleep disturbance? Is there a way we can um in animals that are coming off of opiates? Can we restore their sleeps to normal, so that then they are less likely to do relapse kinds of behaviors, fascinating and I'm? I will certainly have to have you back on to tell us the results of those studies. Meanwhile, I think for anyone, who's trying to come off opiates, exogenous opiates and restore these systems um. What I'm hearing is that it's going to take some time, but that any and all things that people can do to buffer their healthy normal sleep architecture like morning and daytime sunlight, limiting bright light exposure, lowering the temperature at night, a number of things that we've talked About on this podcast deep breathing exercises meditation whatever it is. That helps you calm yourself before sleep yeah right would. This would facilitate not just sleep but perhaps even accelerate the the recovery and um and shorten this period of withdrawal which, from the questions I get and from what I hear um can be absolutely brutal, yeah um. So I can imagine I had to take opiates, for I only took it for three days after giving birth to my um first son. I think Second Son, one of them and um, and just I just said after three days. This is enough. I'M just going to try Tylenol, and so I I leaned myself, not weaned. I just did a sudden sharp cut off, and even though I felt I didn't get the high of opiates when I was taking the um Tylenol codeine um, when I went off it boy, it was like PMS times 100. I was so anxious and upset at little things. It thankfully only lasted a few hours, but if I had taken it for a week or two weeks who knows if that my endogenous opiate receptors would have been permanently down regulated and I would have been an addict, you know an addict, I would have been addicted. I shouldn't say an addict: there's negative connotations: it's just a very physiological state, so no judgments at all associated with it, so um yeah, they're, powerful, powerful painkillers, but can also alter your entire brain and rewire. It yeah well, um. All the more reason why I and many others are grateful that you're doing this work to figure out ways that people can recover um more quickly and more thoroughly. I must say: you've taught us a tremendous amount in um in a relatively short amount of time about the architecture of sleep, the different phases, the relationship between sleep and dreaming, and this incredible structure Locus cerules and I'm so happy. We also got into the ponds that just Delights me because uh we rarely talk about the pawns on this podcast, but such an interesting structure, sex differences that are important in creativity and problem solving and um and Trauma sleep spindles. Just such a wealth of information and much of it, that's actionable for people. So, first of all, I want to say thank you for taking the time to sit down and have this conversation that so many people are sure to benefit from. I also want to thank you for doing the work you do, even though I'm a fellow neurobiologist, I think that um, it's not often that um we take a step back and realize that it's really the work of

um hard thinking hard um strongly motivated pi. It stands for principal investigator by the way pi like yourself graduate students and postdocs that really drive the discovery forward and that lead to these new Therapeutics Physicians are wonderful. Clinicians are absolutely wonderful, but clinicians don't develop new treatments. They only implement the ones that researchers discover. So, thank you for being a brain Explorer with um, with a focus on um growing, the good in the world um. I know I speak for everybody when I say thank you so much. Thank you so much Andrew. Thank you for being an amazing interviewer. You brought a lot out of me in a coherent form fashion that normally, I can't do when I'm speaking in public. I don't know about that. I've heard your lectures and their superb we'll direct people to some of the other ones. Well, thank you, and I also want to put a plug in for graduate students in general and then a key and amazing role that they play in research um. I I'm a pi. As you said, I used to be a graduate student and a postdoc trainee myself doing all of this on the ground. Hands-On experimentation, it's so hard to do it's so hard to do right, it's so hard to think through. All of that now I'm a pi. I get to be an idea, person and just say hey: why don't you do this and hey you know? What do you think about that, and they, of course, intellectually contribute so much to these these planned experiments, but they also do the really hard work, and so I just want to say thank you graduate students, thank you to my graduate students and all graduate students out There thank you, underpaid and and listen and to the major institutions. Stanford UCLA and all other major institutions pay them more. Please! Yes, we need them and they need to have a standard of living. Not I'm not afraid to say that despite my primary employer pay them more, they need it, they deserve it. They deserve it absolutely great. Well, we will absolutely have you back again if you, if you'll be willing - and meanwhile we will

02:02:45 Zero-Cost Support, Spotify & Apple Reviews, YouTube Feedback, Sponsors, Momentous, Neural Network Newsletter, Social Media

Direct people to where they can learn more about you and your exciting work, and once again thanks so much. Thank you so much. Thank you for joining me today for my discussion about sleep, mental health, physical health and performance with Dr Gina Poe. I hope you found it to be as informative and as actionable as I did in fact, I'm already implementing the regularity of bedtime plus or minus half an hour in order to get that growth hormone release, and I can already see both my sleep scores. Improving and my feelings of daytime Vigor and focus and other markers of sleep Health, improving as well, if you're, learning from and or enjoying this podcast, please subscribe to our YouTube channel. That's

a terrific zero cost way to support us. In addition, please subscribe to the podcast on both Spotify and apple and on both Spotify and apple. You can also leave us up to a five star review if you have questions for us or comments or suggestions about guests you'd like me to include on the podcast. Please put those in the comments section on YouTube. I do read all the comments. In addition, please check out the sponsors mentioned at the beginning and throughout today's episode, that's the best way to support this podcast on the Huberman Lab podcast. We often discuss supplements, while supplements aren't necessary for everybody. Many people derive tremendous benefit from them for things like enhancing the quality and duration of sleep, for enhancing focus and for hormone support. The Huberman Lab podcast is proud to announce that we've partnered with momentous supplements we've done that for several reasons. First of all, momentous supplements are of the very highest quality. Second of all, they mainly focus on single ingredient formulations, which is absolutely key. If you want to develop a supplement, regimen, that's most biologically and cost effective. It, for instance, allows you to alternate dosages across days to change the dosages of individual ingredients so on and so forth. In addition, momentous supplements ship internationally, which we know, is important because many of you reside outside of the United States. If you'd like to see the supplements discussed on the Huberman Lab podcast, please go to live, momentous, spelled ous, so that's livemomentis.com Huberman! You can get a 20 discount on any of those supplements. Again, it's livemomentis.com Huberman, the Huberman Lab podcast has a zero cost newsletter. That includes summaries of podcast episodes and toolkits, so checklists of actionable tools that you can use for all aspects of mental health, physical health and performance. You can access this completely zero cost by going to Hubermanlab.com, go to the menu and scroll down to newsletter. Just put in your email, we do not share your email with anybody and you'll get our monthly newsletter, and there are also some examples of previous newsletters, the also there at Hubermanlab.com. If you're not already following me on social media, it is Huberman lab on all platforms. Instagram, Twitter, Facebook and LinkedIn, and at all of those places, I cover science and science related tools, some of which overlap with the content of the uberman Lab podcast, but much of which is distinct from the Hebron Lab podcast content. Again, that's Huberman lab on all social media platforms. Thank you again for joining me for today's discussion with Dr Gina Poe, all about sleep and its relationship to mental health, physical health and performance and last, but certainly, not least, thank you for your interest in science. [. Music]