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. 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. We are now beginning a new topic for the next four to five episodes of the Huberman Lab podcast. Before we move into that I want to just briefly touch on a couple questions that I got from the last episode which was related to the science of endurance training. I described the four kinds of endurance training. We posted protocols of the specific four kinds of endurance training at HubermanLab.com. Just go to that episode you can see the download. It's a zero cost PDF. I got a lot of questions about what's called concurrent training, which is how to program endurance training if you are also interested in training. So how to incorporate strength and hypertrophy training, which was in the previous episode with endurance training. This can all be made very simple. Ask yourself what are you trying to emphasize and then emphasize that for a 10 to 12 week cycle. So if you're mostly interested in endurance, I would say use a three to two ratio, maybe get three endurance training workouts per week, maybe four, and two strength and hypertrophy workouts. If you're mainly focusing on strength and hypertrophy, get three or four workouts for strength and hypertrophy, and do two endurance workouts. Start with the minimum number of sets that's required to get the result that you want. So if you're not accustomed to doing endurance work, you would start with the minimum number that's listed on that protocol. So if it says three to five sets, you would start with three, maybe even just two, and then work your way up by adding sets each week. I do suggest that people get at least one complete rest day per week. I will though I know a lot of people don't like that. I benefit from that. I actually benefit from having two complete rest days each week. I just continue to make progress that way, whether or not it's for strength and hypertrophy or for endurance. I am a big believer in rest days. Other people are not and those could be active rest days, hiking, relaxing, etc. After a 10 to 12 week cycle, then I also suggest taking anywhere from five to seven days completely off. You can still enjoy life and do things. I know for you addicted exercises that you're going to load to do that. But that's one way to stay injury free. Keep your joints and tissues healthy over time and continue to make progress. If you don't want to do that week off, don't do it. None of this is holy. None of it is a strict prescriptive. Just ask yourself, what are you going to emphasize and emphasize that in terms of the total volume of workouts that you do and work up incrementally and then move into another cycle? That's what I suggest. So go to heuromanlab.com. You can get the protocol there. We are now going to move into a new topic unrelated to physical performance starting with this episode. And for the next four to five episodes, we are going to talk all about the senses. That's sight, eyesight, hearing, touch, taste, smell. And we are also going to talk about this critical sense that we call interoception or our sense of our internal real estate. Now the reason that we are talking about the senses is because if you understand how the senses are perceived, what they're about, what the underlying cells and connections are about, you will be in a terrific position to understand the month's topic that follows, which is all about mental health. Now I want to emphasize that if you're somebody who doesn't have any trouble seeing, hearing, tasting, smelling and has an excellent sense of interoception, I do believe that these episodes will still be very relevant to you because they have everything to do with how you move through the world, how you make sense of information and how you organize your thoughts and your emotions. I also want to emphasize that we're going to cover a lot of practical tools. So today's episode is going to be all about vision and eyesight, a topic that's very near and dear to my heart because it's the one that I've been focusing on for well over 25 years of my career. But we're not just going to get into the mechanistic details about how light is converted into electrical potentials and things like that. We are going to talk about practical tools that you can and should use to help maintain the health of your visual system and your eyesight. Very often, young people will say, what should I do? You're always talking about neuroplasticity and how it tapers off over time, but I'm a young person, what should I do? You should absolutely train and support your eyesight. In fact, if you're a young person and you see perfectly, or you feel as if you see the world perfectly, you are in the best position to bolster, to reinforce that visual system so that you don't lose your vision as you age. In addition, you can leverage your visual system for better mental and physical performance and we're going to talk about that. If you're somebody who suffers from a clinical disorder of vision, you have trouble seeing or if you need corrective lenses in order to see this episode is definitely for you. And while of course I can't make clinical diagnoses, I can't have a one conversation with any of you in this format nor am I a clinician, I'm a scientist, not a physician. I did consult with our chair of ophthalmology, Dr. Jeffrey Goldberg at Stanford University School of Medicine, as well as several other people to really vet the information and make sure that the protocols that I'm describing are consistent with the clinical literature. If you have a severe eye problem, you should be working with a really good ophthalmologist and or optometrist, but certainly an ophthalmologist who's a medical doctor. But I do believe that the information that we're going to discuss today is going to be relevant to everybody and we'll set the stage for the month on mental health and mental performance. So let's get started. When we hear the word vision, we most often think about eyesight or our ability to perceive shapes and objects and faces and colors. And indeed, vision involves eyesight, our ability to see shapes and objects and faces and colors and so forth. However, our eyes are responsible for much more than that, including our mood, our level of alertness, and all of that is included in what we call vision. So I just want to take about three, maybe four minutes and talk about how the visual system works, how it's built, and how you are able to so-called see things around you. I also want to describe the ways in which your eyes and your visual system impact your mood and your level of alertness. And then we are going to get right into some protocols, some specific things that each and all of you should do if you want to enhance your vision and maintain your vision as you get older. And again, if you're a 15-year-old or a 12-year-old, this episode is especially for you because your nervous system is far more plastic than mine is. It's much more amenable to change, so you can really build a very strong visual system. And in doing that, and if you adopt specific behaviors at any age of light viewing at particular times and particular ways, then you can build an emotional system that's also reinforced by your visual system. So let's talk about vision. What is vision? Well, vision starts with the eyes. We have no what's called extra-ocular light perception, while it feels good to have light on our skin, while it feels good to be outside in the sunlight for most people. The only way that light information can get to the cells of your body is through these two little goodies on the front of your face. And for those of you listening, I'm just pointing to my eyes. As many of you have heard me say before on this another podcast, your eyes, in particular, your neural retinas are part of your central nervous system. They are part of your brain. They're the only part of your brain that sits outside the cranial vault. In other words, you have two pieces of your brain that deliberately got squeezed out of the skull during development and placed in these things we call eye sockets. There's a genetic program for the specific purpose of making sure that three little layers of neurons, nerve cells, got squeezed out and form what are called your neural retinas. Now, the eyes have a lot of other goodies in them that are very important. And those are the goodies that we're going to focus on a lot today. There's a lens to focus light precisely to the retina. If you're somebody who requires eyeglasses or contacts, chances are you don't do that correctly. And that's why you use other lenses like eyeglasses or contacts. There are also other pieces of the eye that are designed to keep the eye lubricated. You also have these things that we call eyelashes. Most people don't know this, but eyelashes are there to trigger the blink reflex if a piece of dust or something gets in front of your eye. It's a beautiful adaptation of nature. They aren't just aesthetically nice. Costello happens to have very long eyelashes. He gets compliments about this all the time. Maybe you have long eyelashes. I don't have particularly long eyelashes. But the eyelashes are there so that if a piece of dust or something starts to head towards the cornea, the eye blinks very, very fast. It's the fastest reflex you own is your eye blink reflex. We also have these things called eyelids. Now eyelids might seem like the most boring topic of all, but they are incredibly fascinating. Today we're going to talk about how you can actually use your visual system to increase your levels of alertness based on the neural circuits that link your brainstem with your eyelids. And no, we are not going to have a blinking contest because I would win and you would lose. And that wouldn't be fun for you. So let's talk about what the eyes do for vision. Basically the entire job of the eyes is to collect light information and send it off to the rest of the brain in a form that the brain can understand. Remember, no light actually gets in past those neural retinas. It gets to the neural retina. And we have specific cells in the eye called photoreceptors. They come in two different types, rods and cones. Cones are mainly responsible for daytime vision. And the rods are mainly responsible for vision at night or under low light conditions, generally speaking. So basically what happens is if your eyelids are open, light comes into the eye. The lens focuses that light. Light is also just called photons light energy onto the retina. These photoreceptors, the rods and cones, have chemical reactions inside them that involve things like vitamin A. And that chemical reaction converts the light into electricity. Now that might seem incredibly abstract. But the way to think about this is very similar to, for instance, you have touch receptors on your skin. And when you press on those touch receptors, they convert physical pressure into electrical information and those neurons send it up to your spinal cord and brain and can register that somebody or you are touching the top of your hand as I'm doing now. With the eyes and the retina, it's just that light gets converted into electrical information. Within the eye, within the retina, there are then a series of stages of processing. And that information eventually gets sent into the brain by a very specific class of neurons. I would like you to know the names of these neurons. They're called retinal ganglion cells. So the only thing you need to know about the neuroscience of the eye at this point are that they're rods and cones. The cones are involved in bright daytime vision and rods are involved in more dusk or nighttime vision. And you've got these cells called retinal ganglion cells that send the information off to the rest of the brain. Now here's what's incredible. I just want you to ponder this for a second. This still blows my mind. Everything you see around you. You're not actually seeing those objects directly. What you're doing is you're making a best guess about what's there based on the pattern of electricity that arrives in your brain. Now that might just seem totally wild and hard to wrap your head around. But think about it this way because this is the way it actually works. Let's take an example of a color like green or blue. You have cones in your eye that respond best to the wavelength of light that is reflected off, say, a green apple. So you don't actually see the green apple. What you see is the light bouncing off that green apple and goes into your eye and you see it and perceive it as round and green. But not because you see anything green. No green light arrives in your brain. What happens is your brain actually compares the amount of green reflection coming off that apple to the amount of red and blue around it. Well, you might say well the green apple is sitting on a brown table or a white surface. Well, then it will appear very green because the amount of wavelength of light for green is very high and the amount for red is very low. And so it looks very green. So we don't actually see anything directly. What the brain is receiving is a series of signals electrical signals and it's comparing electrical signals in order to come up with what we call these perceptions like I see something green a green apple or I see red. Let me give you a slightly different example. If you were to play a key on the piano, let's say you play not a musician, but I'm going to. So hopefully I won't get this to to incorrectly. But let's say you you have like E sharp. Maybe it's on. If the brain gets that signal, it doesn't actually know E that's what it doesn't recognize it until you were to play it another key next to it. And what it does is does the math it does the subtraction and it compares those two. So when we see something green or we see something red or we see something blue, we're not actually seeing it directly the brain is making a guess about how green or red or blue that thing is by comparing what's around it. Okay, and if that seems hard to wrap your head around, don't worry because we will explain it in more depth going forward. But I really want people to understand this that vision eyesight is not looking at things directly and that information getting directly into your brain. It is translated light information is transformed into electrical signals that your visual system exquisitely understands. Now what does this mean? Why should you care about this? Well, if you have a dog like I do or a cat. They are not color blind, but they lack the the cones that respond to red meaning long wavelength light. So what does that mean? That means that when they see green it's different than the green you see. Not because that apple isn't visible to them, but because they aren't able to compare it to red and you are. As a consequence, when they look at a green lawn, it looks more brownish or orange to them. When you wear a red shirt in front of your dog or cat, if you see a stop sign and they see a stop sign, they see orangeish brown and you see red presuming that you are a tri-cumat meaning you have three color vision. So this is all to say that every animal sees the world differently depending on whether or not they have one or two or three of these different cones, the red, blue or green cones. If you are a mantish shrimp of all things, you see hundreds of colors that human beings can't see. Many animals see into visual ranges that you and I can't see in. So for instance, a pit viper senses heat emissions. It literally sees the heat coming off of you or of an animal that they want to eat. If you are a ground squirrel, you can see ultraviolet light. This is going to sound kind of weird, but ground squirrels actually signal one another by standing up outside and shining sunlight off each other's stomachs to each other signaling at a distance just like you know you could signal somebody with a mirror in sunlight at distance. There are species of primates, this isn't very pleasant to think about that urinate on their hands and then wipe it all over their stomach and then use that sunlight to reflect different signals to each other. I don't know what they're saying. We always assume it's something cute and nice, but maybe they're insulting each other. So this actually gets right down to the heart of these bigger questions like consciousness, what do we see, what's out there, how much of life is really accessible to us. And I could go on and on, you know, this used to be an obsession of mine when I was coming up in the field of visual neuroscience to understand how different animals see the world compared to us. I'll give one more example, a diving bird, you know, a bird that flies over the ocean. It has an incredible task. It has to both view the horizon and it has to view schools of fish and then it has to make a trajectory down into the water and grab one of those fish to eat. And the water has what's called a refractory index. It actually shifts like a prism, the impression or the perception of where that fish is, right? If the bird sees the fish right below it, it has to know it has to adjust its diving trajectory just right because it knows that that fish actually isn't where it sees it. It sees it. It's probably a few inches ahead or to the side of that because of the way that water diverts the image. If you've ever dropped a coin to the bottom of a pool, if you go straight down looking at that location, if you were to look from the top of the pool and you dive straight down with your eyes closed, you will miss because the water refracts. It shifts the visual image. Well, diving birds have an arrangement of these retinal cells that communicate to the brain that's both a streak to view the horizon because they need to know where they are relatives with the horizon and they have a pupil like we do on the bottom of the eye so that they can make very accurate dive and attacks on these schools of fish and catch fish and eat those fish. We just have pupils in the middle of our eyes. So there's a ton about the optics of the eye and the way that it communicates with the brain that allows us to see we could spend hours talking about this, but what I'd like to embed in your mind is that what you experience in the outside world is bottlenecked. It's limited by which wavelengths, which colors, if you will, of light that you can see that your brain is coming up with the best guess about what's there. It doesn't actually know what's there. And that your vision is distinctly different from say the vision of a dog or from the vision of somebody who's a dichromat meaning they don't have a red cone. A lot of people in particular about one in 80 males lacks a red cone and therefore sees the world much the same way that Costello does although he sees it from just much lower toward the ground. So that's what I'd like you to understand about the way the eye communicates with the brain. I would also like you to understand that the brain itself is making these guesses and that those guesses are largely right. How do I know that? Well, they're right because when you reach out to grab a glass most of the time you grab the glass and you don't miss. Right. Most of the time when you make judgments about the world around you based on your visual impression of them, it allows you to move functionally through the world. But let me give you some examples of where this guessing is happening right now and it's so incredible that to this day this still blows my mind. Cover one eye with one hand if you're driving maybe don't do this. If you're viewing the world around you presumably you can see everything that's out there. I could do this with one eye or the other eye. You probably see better out of one or the other and we'll talk about that. You have a giant blind spot in the middle of your visual field. It's called your blind spot. It is the spot in which the connections, the wires from all those retinal ganglion cells exit the back of the eye and head off toward the brain. In other words, you are blind for a huge spot of your central vision, the part of your vision that's highest acuity, highest detail. And yet you don't see that ever. You cover one eye and you see perfectly fine. And it's not just because your eye is moving around really quickly. Your brain is guessing what's in that spot, which is absolutely incredible. And so you don't see that blind spot. This is happening all the time. Now when you have two eyes open, the way that your eyes are positioned in your head and the way they view the world around you, the way that your head and the way they view the world is such that they fill in each other's blind spot. So it's pretty convenient. But if you cover one eye, that's impossible. And yet you still see the world as complete. So the brain is doing these incredible things. It's also creating depth, the sense of depth, even though what arrives from the retina is essentially a read out of a two-dimensional flat image. And it's depth. How do you know depth? Well, this is very simple. Things that are closer to you tend to be larger than things that are far away. Things that are closer to you tend to look like they're moving faster if you've ever been in a train and you look to your side, the rungs on offense or the train tracks going by you, look like they're going very fast. If you look off in the distance, they look like they're moving very slowly. And there are differences between what's close to you and what's further away. So a little house on the horizon, you don't look at and say, oh, that must be a tiny little house. You have some prior knowledge that things further away are smaller. So that's the main way that you do that. And you compare the location at which information about light lands on the two eyes. Eyes are slightly offset from one another. So that, for instance, if I look at you, if you're standing right in front of me right now and I were to look at you, the image of your face, the light bouncing off your face to be more precise lands on one eye and a slightly different location than it does in the other eye. And then the brain does math. It basically does the equivalent of geometry and trigonometry and essentially figures out how far away you are from me, which is just incredible. So the brain does all this very, very fast. And the brain uses about 40 to 50% of its total real estate for vision. That's how important vision is. Now for those of you that are blind or low vision or no vision, that met real estate in the brain will be taken over by neurons that control sense of touch and a sense of hearing. And you're indeed hearing and touch are much better, higher acuity and faster in blind people. But for most of you who I presume are cited, this is how it works. So that's kind of vision from eye to brain in a nutshell. There are a bunch of different stations in the brain that do different things. That's eyesight. Now I want to talk about the other aspect of vision, which is the stuff that you don't perceive, the subconscious stuff. And then we'll transition directly into how you can use light and eyesight to control this other stuff, because it's very important in that other stuff is mood, sleep and appetite. And there are ways in which you can use the same protocols that I will describe in order to preserve and even enhance your vision, your ability to see things and consciously perceive them. So the protocols we will describe have a lot of carryover to both conscious eyesight and to these subconscious aspects of vision. And I just want you to understand a little bit more about the science of seeing of eyesight and vision, and then all the protocols will make perfect sense. So as amazing as eyesight is, it actually did not evolve for us to see shapes and colors and motion and form. The most ancient cells in our eyes and the reason we have eyes is to communicate information about time of day to the rest of the brain and body. Remember there's no extracurricular photo reception. There's no way for light information to get to all the cells of your body. But every cell in your body needs to know if it's night or day. I talked a little bit about this in the episodes on sleep, and this episode is not about sleep, but I want to emphasize that there is a particular category of retinal ganglion cell. Remember the neurons that connect the retina to the brain that is involved in a special kind of vision that has nothing to do with conscious perception of what's around you. And it's happening right now. It's happening all the time. These are so called melanopsin retinal ganglion cells named after the opsin that they contain within them. They are essentially photoreceptors. Remember before I said there are photoreceptors and then these ganglion cells? Well, these melanopsin cells, as the name suggests, melanopsin, have their own photoreceptor built inside them. The opsin that they contain is actually very similar to the melanopsin that is present in the skin of some amphibians, and that causes those amphibians to change their skin color in different light conditions. You have, believe it or not, a little bit of frog skin in your eye, so to speak. Not exactly, but you essentially have the equivalent of what frogs have in their skin in your eye. If you are low vision or no vision, as long as you have retinas, it's very likely you still have these cells, even though you can't see or you don't see well. These cells, retinal ganglion cells, communicate to areas of the brain when particular qualities of light are present in your environment, and signal to the brain, therefore, that it's early day or late in the day. These melanopsin ganglion cells are sometimes also called intrinsically photosensitive cells because they behave like photoreceptors. What do these cells respond to, and why should you care about them? Well, you should care about them because they regulate when you'll get sleepy, when you'll feel awake, how fast your metabolism is, excuse me, your blood sugar levels, your dopamine levels, and your pain threshold. There are other factors that impact those things, but they are one of the most powerful determinant of those other things like mood and pain threshold, sleepiness, wakefulness, etc. These melanopsin ganglion cells have been shown by the night scroope and EITZ up at the University of Washington, and by Samaritara's lab, and David Berson's lab, and a number of other people's labs, such in Panda, and EEPRVENCIO, etc. are a number of excellent labs in neuroscience to set the circadian clock and to respond best to the contrast between blue and yellow light of the sort that lands on these cells when you view the sun when it's so-called low solar angle, when it's low in the sky, either in the morning or in the evening. What does all this mean? It means, and here's the first protocol, and you've probably heard me say this before, but it is appropriate to this episode to say it again, if you are not viewing the sun, sunlight, even through cloud cover, for two to ten minutes in the early part of the day when the sun is still low in the sky, and doing the same thing again in the evening, you are severely disrupting your sleep rhythms, your mood, your hormones, your metabolism, your pain threshold, and many other factors including your ability to learn and remember information. The most central and important aspect of our biology, and perhaps our psychology as well, is to anchor ourselves in time to know when we exist. It sounds a little bit abstract and philosophical, but it's not. We don't know time as a real thing because of watches and clocks. We know time at a biological level based on where the sun is and where, which of course is where we are relative to the sun, because the earth is spinning around. Now, what does this mean for a protocol? It means, see, get that light in your eyes early in the day, and anytime you want to be awake. So try and get as much sunlight in your eyes during the day as you safely can. We'll talk about eye safety this episode in depth. And the blue light and the contrast to that blue yellow. Remember, we don't see blue. This is all subconscious. This is blue reflections coming off of sunlight. Blue light, we've been told is so terrible for us. It is absolutely essential and wonderful for waking up the brain, for triggering all sorts of positive biological reactions, but it needs to be viewed early in the day. If you can't see sunlight because it's the thick cloud cover of say in a, you know, you're in the UK and it's winter, then artificial lights, especially blue lights would be very beneficial to you. You need a lot of this light and its contrast with yellow in order to trigger these melanops and cells, which would then trigger your circadian clock, which sits above the roof of your mouth, which will signal every cell in your body, including temperature rhythms, et cetera. So first things first, your visual system was not for seeing faces, motion, et cetera. The most ancient cells in your eye, which are there right now, as we speak, are there to inform your body and brain about time of day. So you want to get that bright light early in the day, absolutely essential two to ten minutes. You can download the light meter app if you want to measure looks when we, when I explained that I do that in earlier episodes, I got a little convoluted. Get that two to ten minutes, ideally without sunglasses. Now, here's another reason to do this and I've never spoken about this before on any podcast, which is that there have been several studies now in thousands of subjects, exploring what can be done to prevent myopia, near sightedness and other visual defects. And it turns out in a series of large clinical trials, the conclusion is emerged that getting two hours a day of outdoor time without sunglasses, blue light, this blue light that everyone is demonized, getting that sunlight during the day for two hours, even if you're reading other things and doing other things outside has a significant effect on reducing the probability that you will get myopia, near sightedness. Now, whether or not that's also due to the fact that myopia can be caused by viewing things up close to too much. So if you indoors, we tend to be looking at things more closely, right, unless you have a very large house with walls that are very far away from you. But the effect does seem to be directly related to getting sunlight and not just to the distance that you're viewing. I'm going to describe this study just briefly, but this is a second protocol. So we have one protocol about getting sunlight to set your circadian clocks meeting, wake you up, establish your sleep will occur about 12 to 16 hours later. That's all in the sleep episode, but also to enhance your mood, to enhance your metabolism, to optimize your hormone levels and to optimize learning and dopamine levels, this feel good neuromodulator that's essential to not getting depressed for et cetera. But now's a second protocol, which is ideally, and this includes children, as long as they're not very small infants, ideally, we're all getting two hours of outdoor time, even if there's cloud cover. Remember, we evolved mostly under outdoor conditions, not indoor conditions. And no artificial blue light will not replace this aspect of your visual system and offsetting myopia. So I just want to briefly describe this study because it's a very important one, and I don't think it's discussed often enough. There are many studies exploring this, but one of the ones I like the most looked at 693 students and a subset of them were encouraged to spend 11 hours a week outdoors. Okay, so most kids are in school five days a week or so. So they're spending 11 hours a week outdoors. They are sometimes reading outdoors, and I don't always just playing outdoors. They might be reading books, et cetera. They used eight different schools, and the reason they did this study I probably should have mentioned is that myopia, near-signness is a global epidemic, at least that's how it was referred to in the study. I don't know who decides what's an epidemic or not. I think there are thresholds for that. This paper published in the journal Ophthalmology in 2018 described the fact that being outdoors for two hours a day could could significantly reduce the probability that these children would develop near-signness. And it turns out, based on other studies, that adults who spend two hours a day outside, so I would be reading outside, talking outside, no, it does not include light coming through the windshield of your car. I'll explain why in a few moments. Offset the formation of myopia. Now myopia or near-signness has to do with the way that the lens focuses light onto the retina. I don't want to get into a long description of this now, but basically the lens has to bring light to the retina, not in front of it, not behind it. If it brings light to a position in front of the retina, then you won't see clearly. You will need corrective lenses. If it brings light directly to the retina, then you will see clearly. That should be intuitive why that makes sense. So you might say, why would being outside, getting this blue light or this blue yellow contrast from sunlight actually offset myopia? Well, it probably, and I want to emphasize probably, has to do with the fact that these melanopsin ganglion cells, these intrinsically photosensitive ganglion cells are not just responsible for sleep and talking to your circadian clock and that sort of thing, they also make connections within the retina. They connect to things like, this is for the aficionados, the silery body, the iris, the muscles, and the structures within the eye that actually move the lens and allow you to adjust your vision to things up close or far away. And in doing so, they increase or improve the health of the little tiny muscles within the eye that move the lens. And they probably, again, this needs a little bit more work in order to really tamp down the mechanism. They're probably also involved in bringing growth factors and blood supply to the muscles and to the neurons that are responsible for this focusing mechanism within the eye. So remember, your eye is an optical device. You were born with lenses. You don't have to use glasses or maybe you do because you have lenses in your eyes. And those lenses need to move. It's not a, it's not a rigid lens like a glass lens. It's a dynamic lens. It has little muscles that pull on it and squeeze it and make it thicker or thinner as you look at things close and far away. And I'll describe how that works in a moment. These melanops and cells and their activation by sunlight completely subconsciously unaware. You're unaware of this. Promote the health of this system within the eye and allow you to offset the myopia near sightedness. In other words, getting outside for two hours a day each day on average, even if there's cloud cover without sunglasses on will allow you to offset the formation of myopia. Now you might still form myopia if you have certain structural features or genetic basis for that. We will talk about things that you can do as well. But for everybody, we should be doing this and that might seem like a lot, but this is the way that your visual system works. Stay indoors, just getting artificial light and looking at things up close leads to visual defects. It's a form of visual obesity. The posture of your visual system, if you will, is going to be unhealthy if you're just indoors and you're not getting sunlight early in the day and for at least two hours per day. I want to talk a little bit more about how our eyes adjust to things that are close to us or far away. This is an absolutely brilliant consequence of our nature and our design. And whenever I say, nature and design, people always ask me, you know, what are you really trying to say? Are you trying to talk about creators? Are you talking about intelligent design? Look, I want to be very frank with you. I wasn't consulted the design phase and neither were you. And so that is all very interesting, but it's not the topic of this discussion. What is clear and what is the topic of this discussion is that the eye can dynamically adjust where light lands by moving the lens and changing the shape of the lens in your eye through a process called accommodation. And if you understand this process of accommodation, you not only can enhance the health of your eyes in the immediate and long term, but you also can work better. You'll be able to focus better on physical and mental work. You will be able to concentrate for longer. And I want to emphasize that so much of our mental focus, whether or not it's for cognitive endeavors or physical endeavors, is grounded in where we place our visual focus. What we look at and our ability to hold our concentration there is critically determining how we think. So in other words, if you can hold visual focus, you can hold mental focus, cognitive focus, but holding visual focus is challenging. It's tiring because it requires movement of the lens and that movement of the lens requires activation of muscles and the activation of muscles, as you know from the physical performance episodes, if you saw them and even if you don't, is dictated by neurons. So what is accommodation? Well, it's actually very simple and very elegant. And again, this is another case where whenever I look at this stuff, even though I've been looking at it for years, learning about it for years, it still boggles my mind that we have these aparat eye built into our eyes. So we have lenses in our eyes and we have these things called the irises. You're all familiar with the iris because you'll see people's pupils get bigger or smaller and we intuitively think of eyes as having the pupils. If you actually draw two circles on a sheet of paper and you just they look like two circles. But if you put little dots in the middle of them, they look like eyes. Your brain recognizes those as eyes because one of the first things you see when you come into this world are eyes. And actually if you put the little dots close together, it'll look kind of wrong like it's cross-eyed. And if you put them at different locations within those two dots, opposing locations, it'll look Google-eyed. And so your brain is actually filling in all the face and other information, even emotional information, just based on this recognition of eyes. And so there's clearly, we know this. There's real estate, deep up, you know, further up in the brain that's responsible for analyzing and recognizing faces and the eyes and the position of these little things we call irises and pupils, etc. Is really important for how we interpret the status of others. And that's why it's such a powerful thing just to put two circles and move the pupils around on paper. In fact, I want to get into a combination, but if you think about it, if one of my pupils was up there and the other one was down there, one was really big and one was really small, that would actually be a sign of pretty severe damage. If someone gets hit hard on the side of the head, you'll notice that they shine a light in one eye. You know what they're doing that? They're actually looking at the other eye. When you shine light of the eye, that pupil constricts to limit the amount of light that comes in, so it doesn't damage the eye. It also happens when you walk outside and it's bright. It constricts, but we have what's called the consensual pupil reflex. There's a connection deep in the brainstem, deep back here in the brain near my neck. The connects the pupil mechanism for the two eyes and they're looking at the other eye and if you shine light in one eye, and that pupil constricts, but the other one doesn't, there's a good chance there's brainstem damage. This is what they do on the side of a football field or a boxing match or if someone unfortunately hits their head. So two pupils and don't freak out if one pupil is a little bit smaller than the others. Other, that doesn't necessarily mean brain damage, but if you suddenly have one pupil bigger than the other, you absolutely want to go see a neurologist right away. The eyes and the pupils are indicative of things that are happening deep in the brain. Accommodation, his ability to accommodate things that are close here or further away. The way this works is that the iris and the musculature and the structure called the ciliary body move the lens. When you look far away, when you see things far away, your lens actually relaxes. It can flatten out. So I want you to think about this. When you look far away, when it may be anywhere from like 20 feet away from you out to a horizon that's miles or kilometers away from you, the lens can just relax. It can flatten out and you'll notice that it actually is relaxing to look at a horizon. It's relaxing to look far away. Whereas if I look at something up close to me like this pen or my phone or a computer screen or this microphone, it takes effort. You'll sense the effort. Now, some of that effort is actually eye movements because you have muscles that can move your eyes within their sockets. But a lot of the work, quote unquote, is neural work of the muscles having to move and contract such that the lens actually gets thicker in order to bring the light to the retina and not to a location in front of it or behind it. So called accommodation. There's also changes in the size of the pupil as things are closer and further away from you. In fact, there's a simple way to think about this. Healthy pupils are going to dilate when you look at something far away from you. Now, when you see something that excites you or stresses you out, your pupils also get big. Your eyes get wide. But if you look at something far away, your pupils are going to dilate. And when you look at things that are closer to you, when you move them up close, the pupils are going to shrink. That's all part of this accommodation mechanism. Now, you might say, why are you telling me about accommodation? This is crazy. Why are you telling me about this? Well, these days we're spending a lot of time looking at things mainly our phones up close and computers up close and we are indoors. If you are a young person and even if you are 25 or older and you are spending a lot of time looking at things up close and you are not allowing your vision to relax. In other words, you are not giving your lens the opportunity to flatten out and for these muscles to relieve themselves of this work. You may or may not have migraine headaches. You may or may not have headaches. You might and that could be the cause of those. But you are also training your eyes to be good at looking at things up close and not far away. And as a consequence, you are reshaping the neural circuitry in your brain. And it is not good. It is not healthy to only look at things up close. Now, there are a lot of recommendations out there right now, especially with all the lockdowns of the last 12 to 18 months that people should look up from Zoom every once in a while or maybe now I'm hearing that people should take calls instead of doing Zoom or you should look up from your computer screen. It is actually not going to solve the problem just to look up from your computer screen. You need to go to a window. You need to look out at a distance. Ideally, you would even open the window because those windows actually filter out a lot of the blue light that you want during the daytime, a lot of the sunlight. It is actually 50 times less gets through. You want to get out onto a balcony. You want to relax your eyes and look out at the horizon. You want to go into what is called panoramic vision and let your vision expand. You want this lens mechanism to be very elastic. You don't want it to get stuck in that configuration of looking at things up close. A accommodation is a wonderful feature of your visual system but you don't want to push that too hard too often or for too long. You want to view the horizon. You want to get outside. Not just to lighten the load on your mind or to think about other things but to maintain the health of your visual system. In other words, you want to exercise these muscles and that involves both the lens moving and getting thicker and relaxing that lens. The relaxation of the lens is actually one of the best things you can do for the musculature of the inner eye. So what is the protocol? How often should you do this? You might be surprised but for every 30 minutes of focused work, you probably want to look up every once in a while and just try to relax your face and eye muscles including your jaw muscles because all these things are closely linked in the brainstem and allow your eyes to go into a so called panoramic vision where you are not really focusing on anything and then refocus on your work. At least every 90 minutes of looking at things up close or even if you are looking at a television screen or you are watching a movie or your indoors. For every 90 minutes of that, you ideally would have at least 20, probably more like 30 minutes of being outside ideally but if you can't be outside of non-up close vision. You might say that's impossible. How am I supposed to do that? I'm in an office or I'm in a building. Get to a window. Get outside if you can do it safely. Get onto a balcony and just let your eyes relax. Many people are experiencing severe vision problems because they are not getting enough sunlight during the day. They have sleep problems because they are not viewing sunlight early in the day. As I mentioned previous episodes, they are getting a lot of artificial light stimulation in the middle of the night. All of this is through the visual system. Migraines, fatigue, challenges with your eyesight getting worse as you age or even in young people, there is at least according to the articles they described as this epidemic of myopia can largely be dealt with by getting outside going into panoramic vision. Experiencing some distance vision. Look at things off in the horizon. If you're walking or hiking or biking, not looking at your phone the whole time that you're doing that. If you're at the bus stop or you're commuting, certainly not looking at your phone the entire time you're doing that. This is vital. I want to emphasize another protocol, although I don't want to get into it in too much depth because I want to make sure that I also talk about a number of other important aspects of the visual system that are more related to sight. Getting into optic flow is very important for de-stressing your system. When you move through space, whether or not it's through walking, biking, even swimming, if it's self-generated optic flow, so probably not driving or motorcycling, but yes bicycling or unicycling, I don't know, unicycling, I don't know what I thought about unicycling. There used to be a graduate student, Stanford, who is really impressive unicycler. Those are pretty rare. As long as it's self-generated optic flow, meaning you're generating motion of your body and the visual images around you are passing by on your eyes, that is very good for the visual system. And it's very good for the mood systems and the neuromodulator systems of the brain and body that regulate mood. This is well established. So I'm not telling people to get away from their phone and their computers. I spend a lot of time staring at a page, drawing, writing, texting, etc. Just like you do. But we're really talking about some very simple protocols that aren't just designed to improve your sleep, but are really designed to bolster and enhance your vision. And of course, because it's this podcast, we will also talk about things that you can take to improve your vision, but if your visual behavior isn't right, and I do believe we should always start with behaviors and then think about nutrition supplementation, etc. If your behaviors around vision aren't right, you cannot expect to have good healthy eyesight for a long time, meaning throughout your lifespan. For vision is already poor, many of these things that I'm talking about today, perhaps all of them will improve your vision to some degree. And if your vision is starting to go, then doing these behaviors is likely to really enhance the quality of the vision that you will build and maintain over time. And all of these are essentially zero cost. If you live in a very dark environment like a cave or outer space, it's going to be hard to do some of this stuff. But if you're on planet earth, even if there's cloud cover, chances are you can do some or most or even all of these some most or all days. What I'm about to describe next is going to seem so silly on the face of it, but has deep mechanism to support it. Put simply, when you get tired, your eyelids close. And when your alert, your eyelids are open. That is because you have neurons in your brain that depending on your level of alertness will make it easy or hard to keep your eyes open. Now that's a complete duh, except that we don't often think about the relationship between alertness and where we are looking and our eyelids. Now, I learned this from a colleague of mine in psychiatry who happens to work on hypnosis. I'm not going to hypnotize you right now. That's actually for a future episode. But what happens when we get tired? Our eyelids close and our chin moves down. We tend to nod out this way. If you have ever been in a classroom, certainly not one of mine. But if you've been in a classroom and the lecture is kind of drawing on or it's the afternoon, we'll notice that a number of students or heads are choked. Their eyelids are closing and their chin is dropping and then you'll see a bunch of heads bouncing back up. I was definitely one of those people in class. If it was post lunch in the afternoon, it's warm, the hum of the air condition or whatever it is and I just out. When we're wide awake, the opposite happens. Our eyelids are open all the way and our chin happens to be up. And no, this is not me telling you to have a good posture. However, what I learned from my colleague at Stanford is that these circuits actually act in loops when we look up. Maybe it's because these melanopsin cells are in the bottom of our retina. They are. And maybe it's because they're there in order to view sunlight, which is overhead, which it is. But that system of alertness is linked to the position of our eyes. So when we look up and our eyelids are up, it actually has a purpose. It actually creates a wakefulness signal for the brain. And so while this might seem like the silliest and simple tool that I might ever describe on this podcast, if you are feeling tired, it actually can be beneficial to the wakefulness systems of the brain, including the locusts are really is in these areas that release and we're up and effort to actually look up to actually look up toward the ceiling. You don't want your chin all the way back, but to look up and to raise your eyes toward the ceiling and to look up and try and hold that for 10 to 15 seconds. So this isn't looking up and closing your eyes like I don't know any sunny day. That's relaxing. This is looking up and actually looking up at the ceiling. It actually triggers some of the areas of the brain that are involved in wakefulness. So if you're somebody who's falling asleep at your work, this can be very beneficial. Likewise, many people are looking at their phone all day and their chin is down and then they're sitting at a computer that's positioned below them and they're having trouble staying awake or focusing. It can be very, I tell Costello this all the time because he's always falling asleep while he's trying to do his work positioning your computer screen up at eye level or sometimes having it actually above eye level can actually create wakefulness and alertness for the work that you're going to be doing. This is simply because of this connection between the brainstem circuits and the other neural circuits that control wakefulness and eyelids opening and looking up. Okay, so it's again, it's remarkably simple, almost laughably simple, but it's grounded in some of the most hardwired, meaning present from birth aspects of our neural circuitry. And noripinephrine released from locus rulius isn't just a mouthful. It's a really interesting and powerful mechanism for how the rest of the brain wakes up. Locus rulius hoses the rest of your brain with noripinephrine in order to wake up those circuits for work and attention. And so eyes up is actually a way a route into increased alertness eyes down is a route into sleepiness into reduced alertness. And I don't have only one friend that texts up here like on the street holds his phone up here it looks ridiculous. And yet, you know, if we were trying to create more sense of alertness if that's your goal positioning computer screens up high chin up looking up if you need to kind of create an alertness signal not always being chin down and texting or working into typewriter is a reading below us is actually going to send a recurring wakefulness signal. If when things are up we tend to be alert when everything's focused down including your eyes it tends to have a more suppressive or sedative type signaling to the deeper centers of the brain. Now before we move on to the science and tools and protocols related to pattern vision. I want to mention another study that was done by the University of Pennsylvania they have a terrific group that were there that works on sleep that made an important discovery that I think everybody should know about. Which is that children that sleep in rooms that have a night light or dim lights are much more likely to develop myopia near-sightedness. Conversely children that sleep in very dark rooms so either very dim night lights or complete black they have a much lower statistically speaking a significantly lower probability of developing myopia. Nearsightedness now why is that it's because the wavelengths of light that matter for these melanops and cells. Oftentimes can get through the eyelids and that's particularly true for children and people that have thin eyelids some people like me have very thin eyelids I've been told this before. Not many people touch my eyelids but among those that have that very thin eyelids I notice I very thin eyelids compared to say Costello. Now Costello's eyes droopy can't even close his eyes all the way they're so droopy but many people have thin eyelids and those people are going to be even more prone to light coming in through the eyelid. So for parents for kids and for adults you really want to try to get to a place where you can sleep in a completely black or dark environment. One little exposure to light no big deal but this ties back to the other protocol that I've described before in the mood and sleep episodes which is that viewing light even a very low intensity between the hours of 10 pm and 4 am is extremely detrimental to the dopamine and other mood producing systems of the brain. It can negatively impact learning and immunity and even blood sugar and make people type to diabetes prone by way of communication from these melanops and cells to a structure in the brain called the habenula. Why am I throwing out all this verbiage? Well because people have asked for more mechanisms so if you really want to know when you look at blue light or if blue light is getting in through your eyelids in the middle of the night it is likely distorting these lens accommodation mechanism in the eye and leading to myopia in some cases. So that's one reason to avoid blue light exposure and bright light exposure even night light exposure in the middle of the night viewing any light of bright intensity between the hours of 10 pm and 4 am on a consistent basis is going to suppress dopamine because of the way that that light activates these melanops and cells and the habenula and the dopamine system. So it's all very simple get as much bright light as you can can safely right you never want to look at any light so bright that it's painful look at during the daytime. Try and go without sunglasses unless you need them now I wear sunglasses for sake of sport and say when it's really bright out but I try to get two hours a day of working outside or being outside even if there's cloud cover that's going to offset myopia. It's going to help you get better sleep it's going to support mood and metabolism etc and at night if you're sleeping with a lot of lights in the room and especially if there are kids that need a night light you should try and wean them off that night light because it's going to be beneficial for their vision to wean them off that night light and put them into a darker environment obviously you want to get them emotionally comfortable with that first. Now let's talk about pattern vision actual seeing things like faces and colors etc I'm presuming that some of you out there are colorblind we can all help the red green colorblind folks out there by not using red and slides and diagrams and on menus and things of that sort trying to use magenta instead they can see the contrast between magenta and green better than if there's red and green so be kind to the colorblind folks out there it's actually a fair. And there are a lot of different kinds of colorblind as you just mentioned some people are true monochromats they see the world in black and white that's exceedingly rare. Most colorblind people colorblind in quotes are red green colorblind meaning they lack red cone photopigment meaning they can't see long wavelengths of light so they see the world much as a canine or a cat does where they don't get the green red contrast as we call it red green colorblind. They have the green cones but they can't do the contrast comparison that I described at the beginning of the episode so use magenta and they will be able to see things you wonder why stop signs and stop lights and things aren't in magenta well because the world is unkind to the red green colorblind individuals and they have to learn the position of those lights in the in the street lights and they have to learn the shapes of signs which they can do readily and it usually says stop on it as well. But if you care about colorblind folks which I do then we could all do them a service by I think by law actually in the US menus are required to be colorblind accessible. How can you improve your vision? How can you get better at seeing things? Well one way is to make sure that you spend at least 10 minutes a day total at least viewing things off in the distance so that would be well over half a mile or more. Try and see a horizon, try and get your vision out to a location that's beyond the four walls of your house or apartment or the doors of your car and the windshield of your car. I know that can be hard to do but it's very valuable. If you live in a city like New York and it's skyscrapers everywhere you've probably experienced the incredible sense of relaxation and it's aesthetically beautiful when you are walking down one of these long avenues and you turn and I think they have a name for this in New York where the sunset is suddenly visible along a long avenue between some skyscrapers and it's just very relaxing to be able suddenly to see at a distance and that's actually because this eye mechanism relaxing the lens and relaxing some of the musculature around the eyes. Send signals deep into the brainstem that release some of the centers that are involved in alertness, aka stress and it's very pleasant for a reason. It's not a placebo effect if you will. There are a bunch of neurochemicals and things that are associated with that. So try and see at a distance because it's good for your eyesight. It'll keep this lens nice and elastic and the muscles nice and strong that move the lens and it has this relaxing component to it. Now our visual system is exquisitely tuned to motion, not just our self-generated motion but the motion of things around us. And one of the things that it does is something called smooth pursuit. Smooth pursuit is our ability to track individual objects moving as the name suggests smoothly through space in various trajectories. You can actually train or improve your vision by looking at smooth pursuit. Stimulating, that sounds really boring. What you can do is, and I'll provide a link to some that I think are pretty good that are used in various clinics, ophthalmology and optometry clinics. You can actually take a few minutes each day or maybe if you don't do it each day, you could every third day or so. And actually just visually trackable. Sometimes it's moving in in kind of an infinity symbol. Sometimes it's more of a sawtooth. Sometimes it's changing speed. Sometimes the cue that you're following, the little target is dilating and contracting. This is going to keep the muscles, I want to be clear, this is going to keep the extro-ocular muscles conditioned and strong and allow you to have a healthy smooth pursuit system. Remember the brain follows the eye. It follows the movements of the eye. It has to deal with that. And the neural circuits within the brain have to cope with changes in smooth pursuit. So if you're doing a lot of reading up close, you're not viewing horizons, you're not getting a lot of smooth pursuit type stimulation from your life. Or you're just getting it within the confines of a little box on your phone, like your smooth pursuit is over millimeters or what we always talk in terms of visual angle. But the amount of degrees of visual angle, but if you're just looking at smooth pursuit in this little tiny box on your phone or on your computer screen, and you're not looking at objects in your environment like swooping birds and things like that, which I'm guessing many of you are not spending your time in. Well, these mechanisms for smooth pursuit will get worse over time. Your vision will get worse. And so while I prefer that people get out into the real world and experience smooth pursuit tracking of visual objects, maybe it's a good reason to go to a hockey game or, you know, and try and keep your eye on the puck, which I can never seem to do. Move so fast. Or I guess this is a good reason to watch live sports, if that's your thing, or watch a tennis match, like a cat, like a kitten watching the ball go back and forth. Whatever watching kids play, it doesn't really matter. The idea is that you want to use the visual system regularly for what it was designed for and smooth pursuit is a great way to keep the visual and motion tracking systems of the brain and the eye and the extracurricular muscles working in a really nice coordinate fashion. I would say five to ten minutes, three times a week will be great. If you care about your vision, you can train your vision in this way. The other one is to train accommodation. There are a lot of videos out there. I want to be clear on the internet, some of which are from clinicians, some of which are not, some of which are from scientists, some of which are from other sources, talking about things you can do to make your vision better to improve your vision. Most of those are geared toward improving the extracurricular eye muscles. But I did consult with our chair of ophthalmology at Stanford School of Medicine, Jeff Goldberg, who's an MD, NAPHD, a phenomenal scientist and a phenomenal clinician, and incidentally, a phenomenal chairman as well, about what sorts of things, tools are actually beneficial for pattern vision and sight, because there's just so much out there on the internet, not all of which is accurate. And he agreed that a smooth pursuit stimulus, that kind of training, as well as, or exercise, as well as near-for. So spending a few minutes, you might even just do this for two minutes of looking at something up close. That's going to activate these accommodation mechanisms, and then moving it at arm's length and focusing on it for five to ten seconds, maybe more, maybe 15 or 20 seconds, then slowly moving it into a location, and then out. This is actually a lot like the visual training that's done post-concussion to try and repair, actually repair some of the balance and motor and visual and cognitive aspects of the brain. And we are going to have a guest on at a future time that to deal with concussion and some post-concussion training, a lot of post-concussion recovery and training centers around the visual system, not just because people are trying to recover their vision and their sense of balance. But because, as I mentioned earlier, the brain's ability to make sense of its environment and the brain's ability to parse time, not just on the day night schedule, but also shorter time intervals, follows the visual system, something will turn to a little bit more at the end. So what does this mean? The tool is spend two to three minutes doing smooth pursuit. There's some programs on YouTube. You can just look up smooth pursuit stimulus and I'll provide a link to a couple of I like as well. You could do this with a pen if you wanted. You could do this. Someone else could hold a wand and you could do that. If you've got someone that can do that for you. Practice accommodation for a few minutes, maybe every other day. Just bring in something in close. You'll feel the strain of your eyes doing that. I can feel it right now. Move it out. You'll feel a relaxation point. Move it past that relaxation point where you will have to do what's called a virgin side movement to maintain focus on that location. As it moves out, bring it back in at the point where you actually have to go cross side. This will differ for different people depending on how far apart your eyes are so called interpupillary distance. So for me, I have been teased before. I have a very short interpupillary distance. I'm not a cyclops, but I'm hidden there. Some people are more wall-eyed like a flounder. Depending on your interpupillary distance, the point at which things get blurry and cross-eyed will vary. For me, as I get about six inches from my nose, it's really hard. I can't accommodate any longer. I move it out another inch and everything's in nice focus. Try and see whether or not you can get things closer. Now you don't want to get cross-eyed. Remember what your parents told you? My parents told me that if you cross your eyes when you're young, they can stay that way. Actually, they won't necessarily stay that way, but your brain can start losing information. And the ability to see binocular depth, something we'll talk about in a moment. But for now, the protocol would be two to three, maybe five minutes. Just practice that. Practice accommodation. And then be sure to give your eyes some rest. Get outside. Look at a horizon or do nothing. Just kind of let your eyes go soft. I guess what the yogis would call soft gaze. Just kind of relax your eyelids. Not this. Not eyes closed. Just relax. Panoramic vision. Try and see the walls around you without moving your head. Exercise your eye muscles. Exercise the accommodation mechanisms of your eyes. Practice a little bit of smooth pursuit. You don't have to be neurotic about this, but if you do this often enough, meaning every other day, every third day or so, you can be the strange person on the plane or in the classroom doing this. People might chuckle or look at you funny or tease you, but that's okay because you'll be able to see when they are losing their vision. So you'll get the last laugh. Please don't laugh at them, but maybe you can help them at that point. You can hold the pen for them. It's worth doing. It's really worth preserving your vision. And again, if you're a young person, this is great because then you can actually build an extra strong visual system using all the tools that we're describing. I do want to talk about a new set of findings that are related to red light and offsetting age-related macular degeneration. There are a lot of ways in which our visual system gets worse over time. One is so-called age-related macular degeneration. Glenn Jeffrey at the University College London, somebody I've known for decades as a because he's a scientist, has done beautiful work on development and function of the visual system, has published a number of papers recently. One that got a particularly high amount of attention in the press was one that showed that flashing red light into the eyes early in the day, not late in the day. Early in the day can help offset some age-related macular degeneration, presumably by enhancing the mitochondrial function in the photo receptors. There does seem to be some evidence for that, although it's still early days. I want to emphasize you don't want to shine really bright lights into your eyes. You never want to look at any light that's so bright that it's painful. And you never want to force your eyelids to stay open. You need to close your eyes in order to be comfortable. Then chances are that light is too bright. But doing just a couple minutes a day, like two minutes a day of flashing this red light into one eye and then the other, as long as it was early in the day before noon time, and as long as it was in individuals that were 40 years or older, did seem to have a significant effect in offsetting some of the age-related macular degeneration that would otherwise occur. Again, these are early findings. If you want to do this, please be careful. Please talk to your optometrist and endoreophthalmologist. Your eyesight is precious. You don't want to damage it. But it is interesting, and it does seem like red light can improve the function of the mitochondria. These photo receptors have a light of mitochondria, the energy producing organelles within the cells, because they are some of the most metabolically active cells in your entire body. Your photo receptors are active all the time as you're looking around, and even when your eyes are closed, they're active. In fact, through a weird twist of the biology, and please look this up if you're really interested in this, your photo receptors are actually most active in the dark. This is so weird. It's a twist of biology, the way the system's arranged, that when light comes on, they shut off their activity. So actually, whether or not you see something in front of you like this pen or my face, is because the way your photo receptors are turning off, not turning on, it's a really cool twist. And I don't want to go too far down that rabbit hole. But check it out if you're interested in how photo receptors work. It's an absolutely incredible literature. Just Google, excuse me, look up on the web. We are not partial just to Google. I happen to use Google, but use your web browser to look up photo receptors hyperpolarization site. And you can learn a lot about that if you're a real nerd for the stuff like I am. Okay, so red light to the eye can perhaps it seems help maintain vision, doing smooth pursuit exercises and accommodation near far exercises. Some people suffer from poor eyesight simply because their eyes get dry. There are incredible believe it or not lubricating mechanisms for the eye, not just tears, but thin sheet of oil. I mean, it's just amazing unless you have some sort of corneal abrasion, the cornea is the clear stuff on the outside your eye. Corneal abrasion, when you blink, it's smooth. You don't feel it. It's just really, really smooth. And yet if you've ever had a corneal scratch, I've had this. It's really rough. It is so painful. You have a ton of pain receptors in the cornea. The lubrication of the cornea is supported by blinking. And while it seems a little silly, some people actually benefit from doing some five or 10 or 15 seconds of blinking and then doing their focused work. Some people their eyes are drying out because as we focus, if we're trying to do something, our eyelids stay open, the eyes can dry out. But it also can make it such that when we blink the next time, there's a kind of a need to focus because there's some distortions in these oils and liquids across the corneal surface. If you're somebody who suffers from dry eye, I do hope they'll find a treatment or a cure for dry eye soon. There isn't one at present. Someone stands to make a lot of money out there. If you can find a cure for dry eye, let the companies know or start a company right now. It's still a mystery as to how to do that. But blinking for five to 15 seconds probably slowly, not as quickly as I'm doing here on video, but just you know, maybe a blink every second or two for 15 seconds can lubricate the eyes. Not directly really anything neural. It's just going to allow the optics of your eye to be clear, just like when the screen of your phone gets dirty, like when costella is texting on my phone and I pick it up and it's like covered with smudge to clean it off in order to see things clearly the same thing is happening for these optical devices on the front of your brain. Remember, these are brain. Okay, so a lot of protocols today, almost all of them behavioral protocols. I do want to talk a little bit more about vision and how it works internally. And then I also want to talk about some of the foods and supplements that have been shown to support vision and offset visual loss and maybe even reverse some visual loss. Let's talk about binocular vision and lazy eye. I'm very familiar with lazy because when I was a kid, I went swimming one day, one day, and I didn't have my goggles. And so something must have been happening as I recall with the eye moving down through the water. I've always had this problem that I can only do the freestyle stroke off to one side. The people I swim with are always laughing. Somehow I kind of moved toward drowning when I try and breathe on the right side. I think there's some asymmetry in the way I'm organized. Anyway, I was off to my left and my eye kept going in and out of the water. And there was chlorine in the water. And it was making my comfortable side just close my eye. I knew more or less out of swim straight ish might have bounced off the lane lines a few times, but I just used the other eye to kind of steer for that mark on the wall. Got out of the pool. Took a shower, tried off. And then completely lost binocular vision for three days. Completely. The young brain up until about age seven, but maybe even extending out until about age 12 is extremely vulnerable to differences in ocular input between the two eyes. My scientific great grandparents won the Nobel Prize for discovering so-called critical periods periods of time in which the brain is more plastic, more able to change those two guys David, you will Torrance and we will thank you David and Torrance and forever change the face of visual neuroscience. And forever change the way we think about treatment of the young brain. It used to be thought that you wouldn't want to do a surgery on a young kid because of risk of anesthesia and young individuals. But we now know that you need to repair these imbalances that even a few hours. I don't want to scare anybody. I'll talk about reversal, but a few hours of occluding one eye early in life can lead to permanent unless something's done permanent changes in the way that the brain perceives the outside world such that when that eye is opened up again, the brain actually can't make sense of anything that's coming through it. It shuts down that visual pathway somehow. So what happened to me was actually was my eye was fine. I got out of the pool. I opened my eye, but I couldn't see through that eye. Everything was blurry, double vision, unless I covered this eye and then I could see perfectly fine. Fortunately, I went to an ophthalmologist who understood the literature. Thank you, Dr. Mark Loury, who understood the literature and made it clear that what I needed to do was to occlude the other eye. The other eye that was working very well clearly he understood the work of you will weasel now again you don't want to start playing games with this kind of stuff when you're a kid if you wear let's say you have a Halloween costume and you wear an eye patch or a pirate or something for Halloween and you covered up on one side probably for the night of Halloween. It's okay. I do not recommend doing that recreationally. If you don't need that if you're a young child or for your child to do that because indeed you create imbalances in the brain machinery that compares information coming in through the two eyes and it can shut down the neural information for the occluded the closed eye. Now I was able to reverse this issue but my binocular vision has never been terrific. I'm much better at the dart board and still not very good if I close one eye I'm much better at the pool table if I close one eye and I still am terrible. I was the kid in the outfield you know the balls coming towards me the balls coming towards me I'm going to catch the ball and like a hit me square in the in the lip. My binocular vision isn't great as a consequence of this early event and I have a hard time with those binocular stereograms those images that are kind of you're supposed to look at them and then the binocular depth image like pops out people all the other kids were going there's the whatever the statual liberty there's the environment I see I see dots. Okay so I have binocular vision but I use other cues I use the near far cues that I talked about before motion parallax the fact that things are closer to me are moving faster than things further away in order to judge depth and years later when I got involved in and I don't suggest this for most people. I got involved in boxing martial arts was younger you sometimes we'll see fighters this is a slip to avoid getting punched it's also generating motion parallax many animals judge depth by moving their head not by using other mechanisms of accommodation okay so a lot of birds and monkeys and animals will judge depth by moving their head like this or they'll move from side to side animals that will unulate sometimes are actually doing a depth measurement because as you move. Side to side the brain is able to do the math of depth so what does this all mean in terms of protocols if you're a young person do your best to get really good binocular vision not just at level of your phone or your tablet but also at distance you will build strong binocular visual machinery in the brain and at the level of the eyes and the eye musculature. Now if you're somebody who did have an occlusion what's needed is to cover up the other eye to create an imbalance so that the weak eye the so called lazy eye to sometimes refer to as amblyopia that I has to work harder so for me they patched this other eye and made this I eventually got vision through that I back then they open them both up now you might ask what happens if you cover both eyes early in life and this is where it gets interesting you might think well covering one eye leads to poor vision for that I at the end of the day. For that I after that eyes open covering both eyes probably make you blind right actually that's not what happens what human visual discovered in what's been. Affirmed many many more times over in subsequent studies is that it's competitive that the two eyes are competing for real estate up in the brain so if you actually cover both eyes you actually extend the period of the critical of critical plasticity this is a really interesting aspect that other people are starting to leverage now in terms of how to reopen. Plasticity later in life but please don't you know go around with your eyes covered for too long there are some like retreats and stuff where people go into caves with absolutely no vision creates hallucinations we'll talk about why that is in just a moment but here's my suggestion try and get balanced visual input through the two eyes almost everybody has a dominant eye it usually doesn't relate to your dominant hand although it can. And so for me if I cover up my right eye I see much less well much more poorly it's a little bit fuzzy and I have to work harder in order to see the camera for instance then if I cover up my left eye it's actually really easy for me to relax I have a dominant eye you can balance that out by covering up the dominant eye a little bit each day but I would warn any young people meaning you know 12 or younger. Against creating these imbalances if there isn't a clinical need to do that if you do have strong imbalances between the two eyes which can be caused by cataract and lens issues can be caused by neuromuscular issues etc to try and get those dealt with as early as possible by contacting a really good ophthalmologist and ideally a neuro ophthalmologist it is very normal I should say it's very common for young children babies to have an eye that with stribusiness that either dvd. Out or that dv8 in it is important to correct that if you would like to have balanced vision between the two eyes and for the brain to respond equally to the two eyes and to have I would say high fidelity quality vision although some people who have an eye that dress can function normally in life you have an opportunity early in life to rescue that. I will do this but I can actually relax this eye it's so weak in some cases that it actually can start to dv8 here I'll just do this here it's not crossing my eyes so I actually can move my I can misalign my eyes because I have to fight very hard to have the musculature for this eye keep that eye aligned with the other eye and that's because I've been doing eye exercises since I was in my 20s because I noticed when I would study a lot this I would start to drift in I'd start to see double and I would then next thing you know I was just covering the eye up it was getting a little bit more. I was getting weak and weaker just like the atrophy of a muscle so I went to the doctor what did they do they did the exact wrong thing the optometrist I went to give me a prism which adjusted it so that I could see things normally it was just made the eye weaker and weaker it's like putting a weak arm into a sling. So I had to spend at least three years of 10 minutes a day what I recommend doing near far covering up my good eye doing near far with my bad eye and now it's been about 10 12 years that I have pretty decent binocular vision now many of you aren't dealing with this or have these early childhood issues some of you might be experiencing challenges with fatigued eyes or with differences in focus with the two. I exercise of near far smooth pursuit and checking for for dominant and non dominant I can be very beneficial I'm again I'm not a clinician so I don't want to you know give you protocols or enforce protocols on anybody you need to figure out what's right and safe for you giving your vision history I do recommend talking to a really good ophthalmologist if you have severe vision problems of any kind or if you want to offset vision problems of any kind and optometrist as well but ideally would be a neuro ophthalmologist. Okay I did mention hallucinations and they're fun to talk about and think about it for years people have asked why do people get visual hallucinations. Costels in sleep right now you can probably hear him snoring snoring so loud he's probably having hallucinations about rabbits pizza and those are mainly his favorite and sleep he's dreaming about sleep in sleep. hallucinations are a property of the visual system and it was always thought that hallucinations arise because of over activation or activation of certain aspects of the visual system I just briefly want to mention a paper that was published by my good friend and phenomenal scientist and physicists for that matter. Chris Neal who's up at the University of Oregon in Eugene they were studied LSD light compounds and discovered that hallucinations actually occur because portions of your brain become underactive the visual portions of your brain are under stimulated this is probably why when people go into these cave retreats something I've never done I don't think I ever will do where it's completely black. Pretty soon they start hallucinating they start seeing things even though there's nothing there the visual system is desperate to make guesses about what's out in the world it's like the eager beaver of your brain it's like what's out there what's out there what's out there. Even in low to no vision people blind people. There their brain is going to be making guesses about what's out there in the auditory world what sounds are there what what touch sensations are there for sighted folks it's going to be what's out there in terms of light light is the dominant way vision is the dominant way that we evaluate the world around us so it turns out that hallucinations are an under activation of the visual system and then a compensator a compensation by which the visual system creates activity and hallucinations so if you're in the dark long enough you start to hallucinate and see things so that's a little note about hallucinations one of the things that you can do to improve your vision and it's also kind of fun is to put a snow in chart in your home. A snow in chart is that list of letters or if you go to the dreaded department of motor vehicles actually I'm up for renewal soon so I love the department of motor vehicles. The department of motor vehicles have you cover up an eye read the letters on the chart letters of course get smaller and smaller they try to figure out roughly what your vision is cover up the other eye you'll do that some people including nerdy vision scientists like me have had snow in charts in their office or in their home for many years now and you can just practice and you can see how you're doing sitting at a particular distance. Because your level of fatigue and your ability to control that accommodation and other mechanisms of the eye muscles will vary so you can take it as an average it's also a good thing if you're going to get your vision tested for corrective lenses or maybe you're going to do laser surgery or something that sort you're thinking about any of that to really get it measured by professional that the ones that you get in those supermarkets are. Or in many eyeglass stores apologies to the eyeglass stores are often wrong by an order of magnitude and then when you start putting corrective lenses on that are over correcting or under correcting but more often are over correcting then you're essentially weakening the system it's like putting a prosthetic on a limb that you didn't necessarily need or or a robot arm when you didn't need the use of the robot arm although now there's so much excitement about robots I think people are going to be doing that anyway nonetheless. Get your vision tested by somebody who really understands vision like an ophthalmologist or really good optometrist. If you put a snow in chart in your home you know you can do that as part of your visual training now this might seem excessively nerdy but what is more important than your eyesight right eyesight is so vital it's right up there with movement and our ability to move to generate to get up out of chairs and to walk and to run and to take care of ourselves eyesight and movement are the main ways that you can do that. So we are the main ways that we are able to take care of ourselves and take care of others when you start having compromised eyesight or compromise movement people need to take care of us and we become much more challenged in moving through our daily life so while it might seem nerdy to have a snow in chart in your home or to do a smooth pursuit exercise a couple times a week or to get outside for a few hours a day and do your reading or your laptop work there preserving your eyesight and preserving your vision is one of the most life enhancing or quality of life enhancing. So you can do a quality of life enhancing things that you can do and if you are a young person and you can build some of this into your framework of exercise or brain training if you want to call it that that can be immensely beneficial will really set you up to have really good vision over a long period of time. So there are a lot of genetic factors and there are injury related factors that can compromise eyesight and our ability to see and of course this is the things I'm talking about today aren't going to solve all those issues but they can have a tremendous positive impact if you're willing to do just a little bit of work and none of this is involving any cost right just time cost. I do want to talk about a few other things that can perhaps improve vision I want to dispel a few myths about stuff to take to improve vision and then I want to just close by talking about how we perceive time using our vision because that will nicely set the stage for what we're going to talk about next episode. So now you understand a lot about the biology of vision you understand that light has to arrive at the retina and get converted into electrical signals. That process requires things like vitamin A fat soluble vitamin it requires things like the carotenoids that metabolic cascade that biochemical cascade is essential for vision and this is why you've been told that carrots help you see better because they're high in vitamin A. There are a few simple things you can do to support your vision first of all it is true that eating vegetables the dark leafy vegetables and things like carrots that have vitamin A in abundance and eating them in close to their raw form. So naturally occurring foods that contain a lot of vitamin A in their raw form can help support vision. Now does that mean that if you ingest super physiological amounts of that stuff that it's going to make your vision that much better? No, but you do need a threshold level of vitamin A in order to see and into order to see well. Now there's a lot of excitement nowadays about supplementation to help support the health of the visual system and I'm somebody who's pretty open to novel forms of supplementation you probably gathered that if you've been listening to this podcast for a while. You have to determine what's safe and economical and right for you, what your risk tolerance is, etc. But I want to talk about a molecule that's in a lot of supplements to support vision and there are some really good data on and that's lutein. Now the study I want to describe is actually published in 2016 it's from the Journal of Ophthalmology it's a good journal. And the title of this paper is might catch your attention it's increased macular pigment optical density that just means that the macula is an area of the eye for central vision for high acuity vision. Pigment density there is good you want pigment there increase macular pigment optical density and visual acuity visual acuity is your ability to see things in fine detail. And I'm not suggesting you go out and eat raw egg yolks there's the risk of salmonella although I did hear this someone correct me if I'm wrong that the salmonella is actually on the outside of the egg not actually in the egg itself it's on the shell for reasons that relate to how that egg got into the world. That's where the salmonella lives but I could be wrong about that but raw egg yolks are not something that most people want to consume what is this lutein stuff well lutein is in the pathway that relates to vitamin A and the formation of the ops in the photopigment that captures light in the back your eye literally absorbs light pigment in your eye and converts that into electrical signals and allows you to see. And there is some evidence I spoke to our chair of ophthalmology there is some evidence through quality peer reviewed studies that supplementing with lutein can help offset some of the detrimental effects of age related macular degeneration but I want to emphasize but or I'm saying however only for individuals with moderate to severe macular degeneration for people that have normal vision or with a just a low degree of macular degeneration these studies did not see a significant improvement of vision from supplementing with lutein. So I'm not going to tell you to supplement with lutein or not I don't think any study is holy but it does seem that if you have moderate to severe macular degeneration talk to your physician of course talk to your ophthalmologist I'll always say that and I'll say it three times. Supplementing with lutein could perhaps support vision and offset some vision loss in that case probably also talk to your ophthalmologist or consider the red light therapy that I talked about earlier whereas if you have normal vision or a low amount of macular degeneration it does not seem at least from these studies that lutein that much of an effect now I know and I confess I'm sort of of the mind that if I personally had age relay macular degeneration or propensity for it in my family which fortunately I don't but in that case I would think that supplementing with lutein provided it safe could perhaps be of benefit you might want to consider a low dose of that so again I'm not pushing any of this on anybody by any means but you should know that under certain conditions of severe macular degeneration or moderate macular degeneration it does seem like lutein could be beneficial it does not have to be consumed through raw egg yolk. Although that is the highest density source cooking the egg cooking your eggs if you like your scrambled eggs dry or you like your eggs not easy over whatever not runny then you aren't going to get the benefits of the lutein there are other sources of Lucy non animal sources of Lucy as well you can look those up on the internet now there are other compounds that have been shown to perhaps be important for offsetting or helping different forms of vision loss one is I'm going to spell this out I D B E N O N E in the bone in the bend known in the bend known I can never pronounce these compounds forgive me unless I've worked with them there is evidence that it can be beneficial for libers congenital I disease I would definitely go on to them and calm put in I D B E N O N E and for things like libers optical optic neuropathies which is a degenerative condition of the I whether or not people should just be taking this stuff anyway is still an open question there aren't a lot of studies about it a lot of people that are interested in taking things to support their vision are taking lutein as a preventative measure I don't pass any judgment one way or the other typically those supplements also include the z-accessons and the astathaccessons okay the pronunciation of this is is terrible I'm sure but that's not too far off but basically Z E A X N T H I N see what it's our pronounce the A X A N T H I N and the other one is A S T A X A N T H I N both of these have been shown excuse me both of these have been shown to offset some of the corruption in vision that occurs with aging what is a S T A X A X N it's a really interesting compound it's the red pink pigment found in various seafoods shrimp I'm not a big seafood fan but like certain fish like the you'll see at the fish market will have that red pink pigment and it's also in the feathers of flamingos please don't eat the feathers of flamingos and please also don't eat flamingos it's structurally similar to beta carotene so it's very pro pro vitamin A but it has some chemical differences which may make it safer than vitamin A remember vitamin A is a lipid soluble vitamin so it can be stored in our body for long periods of time what is the deal with this A S T A X then you know what are its drawbacks well we can go to our ever favorite examin dot com what does it do well it has a number of different effects a huge number in fact but it does seem to notably increase it's now been shown in three studies the antioxidant enzyme profile it has a number of different effects but the most notable for sake of this episode is the one on ocular blood flow it does seem to increase the amount of ocular blood flow so the blood supply to the eyes so that makes an interesting compound as a number of other effects for whatever reason it also has a notable effect several studies have shown this on fertility in males so it seems to at least double the pregnancy rate when men take astax and then works as in particular it seems here in men that were previously infertile so I don't know if that has something to do with the blood flow to the eyes probably not probably has something to do with something unrelated to the eyes nonetheless that's an effect of this molecule it's also been shown to have positive effects on things like skin elasticity skin moisture skin quality etc probably due to its effects on blood flow so lutein acid axon a stax and t h i n and for people who have concerns about levers optically optically which is going to be a small percentage of people out there but that is a pretty severe condition there are supplements that are available out there I do encourage you as always to talk to your ophthalmologist and physician about them and I will say that there are a number of people that take lutein and some of these other things as a precautionary measure in order to bolster their health and the same way that some people take vitamins and minerals to bolster their help and some people are very health excuse me and some people are very averse to taking vitamins and minerals because they feel like they can get all that from healthy whole foods and of course you can get these things from from whole foods the question is whether or not you can get them in concentrations that are sufficient I do think that in the years to come we are going to see more about lutein I think we are going to see more about some of these other compounds like a stax and hopefully by then I'll be able to pronounce it but at present these things are more or less in the kind of experimental or self-experimental phase there are some good double blind placebo controlled studies like the egg yolk buttermilk study of all things published in really good journals Journal of Ophthalmology, Journal Investigative Ophthalmology and Vision Sciences these are good journals these are journals they are peer reviewed by experts the study that I mentioned earlier about keeping rooms dark that was also published in an excellent journal I think it was JAMA I'll go back and look it's not on my screen any longer but very easy to find and there been some follow-up studies as well from the University of Pennsylvania and other universities so everything I've talked about today relates to studies that were done and published in quality peer reviewed journals that doesn't necessarily mean you want to run out and start taking this stuff that I've described or even doing the protocols I've described I've given you an array a palette of buffet if you will of things that you could do to try and enhance or support your vision depending on how good your vision is your family history of vision and vision loss your occupational hazards you know people that work with metal filings that are flying out of a machine are going to have a higher degree of vision you know risk to the visual system then will people who just do office work although if you're doing a lot of office work chances are you're not getting a lot of long view vision your combination mechanisms are going to start to suffer over time I think we can reliably predict that so I tried to give you an array of behavioral tools and we did touch upon some supplementation tools I be remiss if I didn't say that because blood flow is so critical for the neurons of the brain remember these are the most metabolically active cells in your entire body the cells within your retina because blood flow is required to get them the energy and nutrients they need having a healthy cardiovascular system right doing endurance work doing strength training work regularly is going to support your eyes and your brain in your vision it's indirect but it's essential right it's necessary but it's not going to be sufficient you're going to have to do other things to support your eyesight as well but having a healthy cardiovascular system because it's not going to work so well but having a healthy cardiovascular system because it's going to deliver blood and oxygen and nutrients to this incredible aparaty on the front of your face. These two pieces of brain is going to support your overall brain health and vision over time. So early in the podcast, I talked about how the optimal window for learning is 90 minutes. That's the so-called all-tradian cycle for learning. That's why we held our episodes to about 90 minutes. They're now starting to extend into the hour and 50 minute and two hour mark. That simply reflects my enthusiasm and excitement about these topics and my desire to give you as much information as I possibly can in each episode. Please remember, you don't have to listen to the whole episode all at once. Everything is timestamped. Everything is captioned in English and Spanish. The captions take a few days on YouTube. We apologize for that, but in order to have them done correctly, it takes a few days after it's posted. So if you need those captions, please check back maybe 24 or 48 hours after the episodes are released. If you're enjoying this podcast and the information, if you're finding it beneficial, there are a couple things that you can do that are totally zero cost that really help us and help you get this information going forward. One is, if you don't already subscribe on YouTube, please do subscribe. We release episodes every Monday and hopefully soon, more often than that, shorter episodes as well. But every Monday, we release an episode. Please do subscribe. If you don't already subscribe on Apple and Spotify, that's very beneficial. Please do that. That helps us as well. If you could give us a five star review on Apple, if you feel that that's what we deserve and Apple also gives you the opportunity to give us comments feedback about the episodes. If you have suggestions about episodes, feedback of any kind, please put it in the comment section on YouTube. Routinely throughout the week after the release of each episode, I cover content in shorter format and in more depth on Instagram at HubermanLab. Every episode is also indexed and searchable in the search function on our website, HubermanLab.com. That's also where we post links to various studies and downloadable protocols, all zero cost. And as I mentioned, you can search for different topics and it will bring you to the particular episodes that contain the information on those topics. If you'd like to support us on Patreon, we have a Patreon account. It's patreon.com slash Andrew Huberman. There you can support us at any level that you like. As well, if you'd like to support us, please check out our sponsors. The sponsors that we've discussed at the beginning of the podcast are vital way to keep the information being distributed at zero cost to everybody. We only work with sponsors that we really love their products and that we really respect the people that we're working with there. And of course, there's no obligation to purchase or to even check out those sponsors. But if you're in a position to do so, that really does help us. Routinely throughout the podcast, we talk about supplements. There are a lot of supplement companies and sources of supplements out there. The one that we work with and that we partnered with is Thorne THORNE because Thorne has the highest levels of stringency in terms of what they say is in their supplements, is actually in their supplements because it's independently tested and verified as well as the amounts that they list on the bottles actually are matched by what's in the capsules and tablets. That's a serious problem in the supplement industry and Thorne deals with that problem by being very truthful and very accurate about what's in their supplements and how much of those things are in there. If you wanna see the supplements that I take, you can go to Thorne THORNE.com slash the letter U slash Huberman. There you'll see all the supplements that I take. You can get 20% off any of those supplements as well as 20% off any of the other supplements that Thorne happens to make if you happen to navigate into their website through that portal, Thorne.com slash the letter U slash Huberman. And last but not least, I want to thank you for your time and attention today. Your willingness to learn about vision in the visual system and the various things that you can do to help support the health and functioning of your visual system. And of course, I want to thank you for your interesting silence. Thank you for your time and attention today.