

The Science of Vision, Eye Health & Seeing Better | Huberman Lab Podcast #24

This episode I describe how we see, meaning how our eyes focus, convert light information into electricity the rest of the brain can understand and how our brain creates the incredible thing we experience as “sight”. I also describe how we can train and support our visual system to improve at any age. I describe more than a dozen protocols to support depth perception, offset near-sightedness, improve mood, sleep, and our ability to focus (both visual focus and our mental focus generally). I also explain how to use eyesight to improve our levels of alertness and why visual hallucinations, lazy eyes and colorblindness occur. I also describe various compounds that may assist in supporting visual health and possibly improve our vision. Many simple, zero-cost protocols and a lot of scientific mechanisms are covered in this episode in clear language anyone can understand-- it is for anyone that values their brain and their eyesight, whether young, adult-age or advanced age.

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Link to eye exercise videos for smooth pursuit, amblyopia, etc.

(Numbering of videos does correspond to numbers in episode caption.)

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- Welcome to the Huberman Lab Podcast, where we discuss science and science-based tools for everyday life. [gentle music] 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. In keeping with that theme, I'd like to thank the sponsors of today's podcast. Our first sponsor is Roka. Founded by two All-American swimmers from Stanford, Roka eyeglasses and sunglasses have really been designed with the utmost care and the utmost attention to the science of optics and the visual system. So one of the things I like so much about Roka eyeglasses and sunglasses is that they're extremely lightweight. If you get sweaty, so for instance, if you wear them while running, or walking, or hiking, they don't slip off. And with the sunglasses, when you're outdoors, if there's cloud cover, or if there's shadows, or if the day gets brighter or dimmer, you can still see your surroundings perfectly well. And that's because the designers at Roka really understand the way the visual system works how it habituates,

how it adapts. You don't need to understand the science behind all that, but they do, and as a consequence the eyeglasses perform extremely well under all conditions, whether or not that's indoors or outdoors. So they put a ton of science and purpose into the design. They also happen to look really good. They have a really nice aesthetic. A lot of, as you know, performance active wear eyeglasses look rather ridiculous, but the Roka glasses, I think, have a very nice aesthetic to them that you can wear anywhere. If you'd like to check out Roka glasses, you can go to Roka, that's roka.com and enter the code Huberman at checkout, and you'll get 20% off your first order. That's Roka, R-O-K-A .com and enter the code Huberman at checkout for 20% off your order. Today's podcast is also brought to us by Inside Tracker. Inside Tracker is a personalized nutrition platform that analyzes data from your blood and DNA to help you better understand your body and reach your health goals. I'm a big believer in getting regular blood work done for the simple reason that many of the factors that impact our immediate and longterm health can only be analyzed from a blood test. And now, with the advent of modern DNA tests, we can also get insight into our specific DNA makeup and how that influences our lifestyle choices and our health status. The problem with a lot of blood tests is that you get a lot of information back, but you don't always know what to do with that information. With Inside Tracker, they have a very easy to use, personalized dashboard platform that informs you what sorts of lifestyle, nutrition, exercise, changes you might want to make, according to the levels of particular metabolic factors, hormone factors, et cetera, in your blood and DNA. So it makes everything very simple, both in terms of where you're at health-wise and what you should or could do, in order to improve your health, something I do believe most everybody would like to do. With Inside Tracker, it makes all that very easy. They also have something called the inner age test. This is a test that shows you what your biological age and compares to that, of course, to your chronological age. And, of course, your biological age is really what you want to know, because it's a predictor of how long you're going to live and the quality of your life. If you'd like to try Inside Tracker, you can visit insidetracker.com/huberman. And if you do that, you'll get 25% off any of Inside Tracker's plans, just use the code Huberman at checkout. Today's episode is also brought to us by Helix Sleep. Helix Sleep makes mattresses and pillows that are ideally suited to your sleep needs. Everybody needs something different in terms of what to sleep on. Some people like a hard mattress. Some people like a soft mattress. Some people tend to run warm. Some people tend to run cold. With Helix Sleep, you go to their website, you take a very brief two-minute quiz, and you answer

some questions such as, do you tend to sleep on your stomach, or your side, or your back? Maybe you don't know. Do you tend to run hot or cold, et cetera. At the end of that quiz, you match to a specific mattress. I took that quiz about six months ago, and I matched to the Dusk Mattress, and I've been sleeping on a Dusk mattress from Helix for the last six months, and I've been sleeping better than I ever have before. Basically, everyone's unique, and Helix understands that, and that's built into the design of their mattresses and this two-minute quiz that you take to match you to one. If you'd like to try a Helix Sleep mattress, you can go to helixsleep.com/huberman, take their two-minute quiz, and they'll match you to a customized mattress. You'll also get up to \$200 off any mattress order and two free pillows. They make terrific pillows. You'll get a 10-year warranty on that mattress, and you get to try it out for 100 nights risk-free. If you don't like it, they'll come pick it up and take it away. You won't get charged, you'll get your money back, et cetera.

00:04:51 Protocol: Concurrent Training For Endurance, Strength, Hypertrophy

So that's helixsleep.com/huberman for up to \$200 off and two free pillows. 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 strength and hypertrophy training. Or 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. And although 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, et cetera. 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 exercisers that you're going to loathe 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 hubermanlab.com,

00:07:24 The Senses, Vision, Seeing & What We Should All Do To See Better

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're 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 know, you're always talking about, you know, 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-to-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

00:10:35 Our Eyes: What They Really Do, & How They Work

and will 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 extraocular 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 and other podcasts, 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 so, 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,

00:14:30 Converting Light Into Electricity Language: Photoreceptors, Retinal Ganglion Cells

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 pressure, physical pressure, into electrical information and those neurons send it up to your spinal cord and brain, and you 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 there are 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.

00:17:00 We Don't See Anything Directly: It Is All A Comparison Of Reflected Light

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 it 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, okay? 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, I'm not a musician, but I'm going to, so hopefully I won't get this too incorrectly but let's say you have like E sharp, and maybe it's like ding, ding, ding, ding, ding. 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 another key next to it, dun, dun, dun, dun, and what it does, it 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?

00:19:35 Dogs, Cats, Snakes, Squirrels, Shrimps, Diving Birds, & You(r View Of The World)

Why should you care about this? Well, if you have a dog like I do, or a cat, they are not

colorblind, but they lack 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 is invisible 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 orangish-brown, and you see red. presuming that you are a trichromat, 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 mantis shrimp of all things, you see hundreds of colors that human beings can't see, okay? Many things 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 kind of 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. You know, 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'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, 'cause they need to know where they are relative to the horizon, and they have a pupil like we do on the bottom of their 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 a 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 1 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.

00:24:05 Everything You See Is A Best Guess, Blind Spots

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 is such that they fill in each other's blind spots, so it's pretty convenient. But if you cover one eye, that's impossible, and yet, you still see the world as complete.

00:25:50 Depth Perception

So the brain is doing these incredible things. It's also creating depth, a sense of depth. Even though what arrives from the retina is essentially a readout of a two-dimensional, flat image, so it can sense 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 a fence, 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 it 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. So your eyes are slightly offset from one another. So that, for instance, if I look at you, if you were 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 in 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 real estate in the brain will be taken over by neurons that control sense of touch and a sense of hearing, and your, indeed, hearing and touch are much better, higher acuity, and faster in blind people. But for most of you, who I presume are sighted, 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,

00:28:00 Subconscious Vision: Light, Mood, Metabolism, Dopamine; Frog's Skin In Your Eyes

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 and 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 carry over 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 extraocular 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. And I talked a little bit about this on the, 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. So you have, believe it or not, a little bit of frog skin in your eye, so to speak. Okay, not exactly, but you essentially have the equivalent of what frogs have on 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, if not the most powerful determinant, of those other things like mood and pain threshold, sleepiness, wakefulness, et cetera. These melanopsin ganglion cells have been shown by the Nitz Group, N-I-T-Z, up at University of Washington, and by Samer Hattar's lab and David Burson's lab, and a number of other people's labs, Satchin Panda, Prevecio, et cetera,

00:32:00 Blue-Yellow Light, Sunlight; & Protocol 1 For Better Biology & Psychology;

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 the cells when you view the sun, when it's a 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 is appropriate to this episode to say it again. If you are not viewing the sun, sunlight, even through cloud cover, for two to 10 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. Okay, it sounds a little bit abstract and philosophical, but it's not. And 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 of 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 a, you know, you're in the UK and it's winter, then artificial lights, especially blue lights, would be very beneficial to you. We need a lot of this light and its contrast with yellow, in order to trigger these melanopsin cells, which will 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 10 minutes, you can download the light meter app if you want to measure lux. When we, when I explained how to do that in earlier episodes

00:35:00 Protocol 2: Prevent & Offset Near-Sightedness (Myopia): Outdoors 2 Hours Per Day

it got a little convoluted, get that two to 10 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, nearsightedness, and other visual defects. And it turns out, in a series of large clinical trials, the conclusion has emerged that getting two hours a day of outdoor time without sunglasses, blue light, this blue light that everyone has 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, nearsightedness. 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're 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, meaning 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, et cetera. But now's the 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 liked 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. They're not always just playing outdoors, they might be reading books, et cetera. They used eight different schools. And the reason they did the study, I probably should have mentioned, is that myopia, nearsightedness, 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 significantly reduce the probability that these children would develop nearsightedness. And it turns out based on other studies, that adults who spend two hours a day outside, that 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 nearsightedness, 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 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, why it makes sense. So you might say, well, 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 ciliary 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 rigid lens, like a glass lens. It's a dynamic lens, and 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 melanopsin 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, nearsightedness. 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 a 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. Staying indoors, just getting artificial light, and looking at things up close leads to visual defects. Okay, it's a form of kind of like visual obesity, right? 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 at the design phase,

00:42:00 Improving Focus: Visual & Mental; Accommodation, Your Pupils & Your Bendy Lens

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, okay? 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 for years, learning about it for years, it still boggles my mind that we have these apparatus built into our eyes. So, we have lenses in our eyes, and we have these things called the irises. You know, 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, of 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 in, 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, et cetera, 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, you know, move the pupils around on paper. In fact, I want to get into accommodation, 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 why 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. This 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, that 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, you know, 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 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. So, the eyes and the pupils are indicative of things that are happening deep in the brain. Now, accommodation is our ability to accommodate to things that are up close here or further away. And the way this works is that the iris, and the musculature, and a structure called the ciliary body move the lens. So, when you look far away, okay, 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,

00:48:50 Protocol 3: Distance Viewing For 20min For Every 90 Minutes of "Close Viewing"

especially with all the lockdowns of the last, you know, 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, where you should look up from your computer screen. It's 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's 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's 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. 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 kind of thicker and relaxing that lens. And the relaxation of the lens is actually one of the best things you can do for the musculature of the inner eye. So what's 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 and 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're just 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're looking at a screen, you know, television screen, or you're watching a movie, or you're 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. And you might say, that's impossible, how am I supposed to do that? You know, 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're not getting enough sunlight during the day. They have sleep problems, because they're not viewing sunlight early in the day. And as I've mentioned in previous episodes, they're getting a lot of artificial stimulation, artificial light stimulation, of the eye in the middle of the night, all of this is through the visual system. So migraines, fatigue, challenges with your eyesight getting worse as you age, or even in young people, there's a, you know, at least according to the articles, they describe it as this epidemic of myopia can largely be dealt with by getting outside, going into panoramic vision, experiencing some distanced 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. So this is vital. And I want to emphasize another protocol, though I don't want to get into it in too much depth,

00:52:20 Protocol 4: Self-Generated Optic Flow; Move Yourself Through Space Daily

'cause 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, but 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 I don't know, unicycling. I don't know why I thought about unicycling. There used to be a graduate student at Stanford who was a really impressive unicyclist, 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, et cetera, 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, et cetera, if your behaviors around vision aren't right, you cannot expect to have good, healthy eyesight for a long time, meaning throughout your lifespan. And if your 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, okay? 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,

00:54:26 Protocol 5: Be More Alert; Eyelids, Eye Size, Chin Position, Looking Up Versus Down

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 you're 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 lecturer is kind of drawing on, or it's the afternoon, what you'll notice is that a number of students, their heads are jolt, kind of their eyelids are closing, and their chin is dropping, and they, you'll see a bunch of heads bouncing back up, right? 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 conditioner, or whatever it is, and I'm just out, okay? 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 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 locus coeruleus and these areas that release norepinephrine 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 on a nice 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, 'cause 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 do. 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, 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 norepinephrine released from locus coeruleus isn't just a mouthful, it's a really interesting and powerful mechanism for how the rest of the brain wakes up. Locus coeruleus hoses the rest of your brain with norepinephrine, 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 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 typewriters, or reading below us. is actually going to send a recurring wakefulness signal. When things are up, we tend to be alert. When everything's focused down, including our eyes, it tends to have a more suppressive or sedative type signaling

00:59:21 Protocol 6: Sleep In A Very Dark Room To Prevent Myopia (Nearsightedness)

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 there that works on sleep. They made an important discovery that I think everybody should know about, which is that children that sleep in rooms that have a nightlight or dim lights are much more likely to develop myopia, nearsightedness. Conversely, children that sleep in very dark rooms, so either very dim nightlights 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 melanopsin 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, I have very thin eyelids. I notice I have very thin eyelids compared to say, Costello. Now, Costello's eyes droop. He 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 10:00 PM and 4:00 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 two diabetes prone by way of communication from these melanopsin 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 this 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 nightlight exposure, in middle of the night. Viewing any light of bright intensity between the hours of 10:00 PM and 4:00 AM on a consistent basis is going to suppress dopamine, because of the way that that light activates these melanopsin cells, and the habenula, and the dopamine system. So it's all very simple, get as much bright light as you 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 sake 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, et cetera. And at night, if you're sleeping with a lot of lights in the room, and especially, if there are kids that need a nightlight, you should try and wean them off that nightlight, because it's going to be beneficial for their vision to wean them off that nightlight and put them into a darker environment. Obviously, you want to get them emotionally comfortable

01:02:55 Color Vision, Colorblindness, Use Magentas Not Reds,

with that first. Now, let's talk about pattern vision, actual seeing things, like faces and colors, et cetera. 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 in slides and diagrams, and on menus, and things of that sort. Try and 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 percentage. And there are a lot of different kinds of colorblind. I should just mention 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 photo pigment, 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. That's why 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 color blind individuals, and they have to learn the position of those lights 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 U.S.,

01:04:32 Protocol 7: Keeping Your Vision Sharp With Distance Viewing Every Day

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 of relaxing the lens and relaxing some of the musculature around the eyes sends 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, 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,

01:06:05 Protocol 8: Smooth Pursuit

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 stimuli, and 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 track a ball. Sometimes it's moving in and 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 extraocular 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, you know, 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 doing, 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, I don't know, 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. It moves so fast. Or I guess this is a good reason to watch live sports if that's your thing, or to 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 extraocular muscles working in a really nice coordinate fashion. I would say five to 10 minutes,

01:08:48 Protocol 9: Near-Far Visual Training 2-3 Minutes 3-4 Times a Week

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 extraocular eye muscles, but I did consult with our chair of ophthalmology at Stanford School of Medicine, Jeff Goldberg, who's an MD and a PhD, 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 or good, frankly. And he agreed that a smooth pursuit stimulus, that kind of training, as well as, or exercise, as well as near far. 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 arms length, and focusing on it for five, 10 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 we'll 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, or you can just look up smooth pursuit stimulus, and I'll provide a link to a couple 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 bringing 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 the vergence eye 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-eyed, 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

heading there. Some people are more walleyed, like a flounder. Well, depending on your interpupillary distance, the point at which things get blurry and cross-eyed will vary. But for me, you know, as I get about, oh gosh, I guess it's 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, or my parents told me, that if you cross your eyes, when you're young, that 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, you know, 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 relaxed, 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. You know, that 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,

01:13:33 Protocol 10: Red Light, Emerging Protocol To Improve Photoreceptors & Vision

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, but one is so called age-related macular degeneration. Glen 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 photoreceptors. 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. If you need to close your eyes in order to be comfortable, well, 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/or ophthalmologist. 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 photoreceptors have a lot of mitochondria, the energy-producing organelles within the cells, because they are some of the most metabolically active cells in your entire body. Your photoreceptors 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 photoreceptors 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 photoreceptors 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 photoreceptors 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 photoreceptors hyperpolarization site. And you can learn a lot about that, if you're a real nerd for this stuff, like I am.

01:16:20 Dry Eyes; Blinking, Protocol 11

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 a 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 of 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, you know, 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 15 seconds, probably slowly, not as quickly as I'm doing here on video, but just, you know, maybe a blink every a second or two for 15 seconds can lubricate the eyes. And that's not directly related to 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 Costello's 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,

01:18:40 Lazy Eye, Binocular Vision, Amblyopia; Triggering Rapid Brain Plasticity; Protocol 12

and maybe even reverse some visual loss. Let's talk about binocular vision and lazy eye. I'm very familiar with lazy eye, 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 move 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 own uncomfortable, so I just closed my eye. I just decided, you know, I knew more or less how to swim straight-ish. Might've bounced off the lane lines a few times, but I just use the other eye to kind of steer for that mark on the wall. Got out of the pool, took a shower, dried off, and then completely lost by 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 Hubel and Torsten Wiesel, thank you, David and Torsten, forever changed the face of visual neuroscience and forever changed 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 in young individuals. But we now know that you need to repair these imbalances, that even a few hours, okay, 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, I 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 Lurie, who understood the literature and made it clear that what I needed to do was to occlude the other eye, the eye that was working very well. Clearly, he understood the work of you Huber and Wiesel. 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, you're a pirate or something for Halloween, and you cover it 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, you know, in the outfield. You know, the ball is coming towards me, the ball's coming towards me, I'm going to catch the ball, and like it hit me square 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. All the other kids were going, oh, there's the, whatever, the Statue of Liberty. There's the [inaudible], and 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 and martial arts when I was younger. You sometimes will 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 undulate sometimes are actually doing a depth measurement, because as you move from 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, this is sometimes referred to as amblyopia, that eye has to work harder. So for me, they patched this other eye and made this eye, eventually, I got vision through that eye back. then they opened 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, if covering one eye leads to poor vision for that eye after that eye is open, covering both eyes will probably make you blind, right? Actually, that's not what happens. What Hubel and Wiesel discovered and 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 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. It creates hallucinations. We'll talk about why that is in just a moment, but here's my suggestion.

01:24:48 Protocol 12: Determine Your Dominant Eye; Near-Far Training

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. Now, 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. And 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, et cetera, 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 strabismus, that either deviates out or that deviates in. It is important to correct that. If you would like to have balanced division 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 drifts can function normally in life, you have an opportunity early in life to rescue that. I won't do, well, maybe I will do this, but I can actually relax this eye. It's so weak, in some cases, that it actually can start to deviate. 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 twenties, 'cause I noticed when I would study a lot, this eye 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, and it was getting weaker 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 gave me a prism, which adjusted it so that I could see things normally, which 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, is 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 eyes. These eye exercises of near-far, smooth pursuit, and checking for dominant and non-dominant eye 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, given 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. An optometrist as well,

01:27:57 Visual Hallucinations: The Consequence of An Under-Active Visual Brain

but ideally would be a neuro-ophthalmologist. Okay, I did mention hallucinations, and they're fun to talk about and think about. And for years, people have asked, why do people get visual hallucinations. Costello's in sleep right now, you can probably hear him snoring, he's 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 physicist for that matter, Cris Niell who's up at the University of Oregon in Eugene. They 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, they are, their brain is going to be making guesses about what's out there in the auditory world. What sounds are there? 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 compensatory, a compensation, by which the visual system creates activity and hallucinations. So if you're in the dark long enough,

01:29:47 Protocol 13: Snellen Chart: A Simple, Cost-Free Way To Test & Maintain Vision

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 Snellen chart in your home. A Snellen 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, they'll have you cover up an eye, read the letters on the chart, the letters of course gets smaller and smaller, they're trying 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 Snellen 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. Your, this is something that's not often mentioned, but your performance on the Snellen chart will vary depending on time of day, 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 of that sort, if you're thinking about any of that, to really get it measured by a professional. The ones that you get in those supermarkets, 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, well, then you're essentially weakening the system. It's like putting a prosthetic on a limb that you didn't necessarily need, or 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 a really good optometrist. If you put a Snellen 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 we are able to take care of ourselves and take care of others. When you start having compromised eyesight or compromised 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 Snellen chart in your home, or to do a smooth pursuit exercise a couple of 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 things that you can do. And if you're 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 and will really set you up to have really good vision over a long period of time. Now, of course, there are genetic factors, and there are injury-related factors that can compromise eyesight and our ability to see. And, of course, the things I'm talking about today aren't going to solve all those issues,

01:33:00 Vitamin A, Lutein, Idebenone, Zeaxanthine, Astaxanthin, Blood Flow

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? It's just time cost. So I want, 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, a fat soluble vitamin. It requires things like the carotenoids. That metabolic cascade, the biochemical cascade, is essential for vision. And this is why you've been told that carrots help you see better 'cause 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 in 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've probably gathered that, if you've been listening to this podcast for awhile. You have to determine what's safe, and economical, and right for you, what your risk tolerance is, et cetera. 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, it might catch your attention, it's "Increased macular pigment optical density," that just means that 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. "Following consumption of a buttermilk drink "containing lutein-enriched egg yolks." Remember, raw foods? Lutein-enriched egg yolks. Sounds like a Rocky movie, where he would drink the raw egg yolks. "A randomized double-blind placebo controlled trial." Now, 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, but 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 of 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 emphasize 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 had much of an effect. Now, I know, and I confess I'm sort of of the mind that if I personally had age-related macular degeneration, or a propensity for it in my family, which fortunately I don't, but in that case, I would think that supplementing with lutein, provided it's 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 can be beneficial. It does not have to be consumed through raw egg yolks, although that is the highest density source. Cooking the egg yolk, cooking your eggs, if you like your scrambled eggs dry, or you like your eggs not easy over or whatever, not runny, then you aren't going to get the benefits of the leucine. There are other sources of leucine, non-animal sources of leucine 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-E-B-E-N-O-N-E, idebenone, idebenone, idebenone, I can never pronounce these compounds, forgive me, unless I've worked with them. There is evidence that it can be beneficial for Leber's congenital eye disease. I would definitely go on to examine.com, put in I-D-E-B-N-O-N-E. And for things like Leber's optic neuropathies, which is a degenerative condition of the eye, 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 zeaxanthins and astaxanthins. Okay, the pronunciation of this is terrible, I'm sure, but that's not too far off, but basically Z-E-A-X-A-N-T-H-I-N. You can see why it's hard to pronounce, Z-E-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 disruption in vision that occurs with aging. What is astaxanthin? It's a really interesting compound. It's the red-pink pigment found in various seafoods. So 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 betacarotene, so it's very 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 astaxanthin? You know, what are its drawbacks? Well, we can go to our ever favorite examine.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 it an interesting compound. It has 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 astaxanthin and 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. It 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, et cetera, probably due to its effects on blood flow. So lutein, astaxanthin, A-S-T-A-X-A-N-T-H-I-N, and for people who have concerns about Leber's optic neuropathies, 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 in the same way that some people take vitamins and minerals to bolster their health, and some people are very health, excuse me, and some people are very averse to taking vitamins and minerals, 'cause they feel like they can get all that from healthy, whole foods. And of course, you can get these things 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 astaxanthin, 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 of Investigative Ophthalmology and Vision Sciences, these are good journals. These are journals 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.

01:44:20 Summary of Protocols, Vital Point About Blood & Oxygen For Vision

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, a 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 machines are going to have a higher degree of vision, you know, risk to their visual system than well, 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 accommodation mechanisms are going to start to suffer over time. I think we can reliably predict that. So I've tried to give you an array of behavioral tools, and we did touch upon some supplementation tools. I'd be remiss if I didn't say that, because blood flow is so critical for the neurons of the eye, 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, and 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 going to deliver blood and oxygen and nutrients to this incredible apparatus 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.

01:46:00 Episode Length, Captions, Zero-Cost Support, Instagram, Searching Topics

That's the so called ultradian cycle for learning. That's why we had all 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 of 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 @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/andrewhuberman. 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 discussed at the beginning of the podcast are a 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, T-H-O-R-N-E, 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 want to see the supplements that I take, you can go to Thorne, thorne.com/u/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/u/huberman. And last but not least, I want to thank you for your time and attention today. Your willingness to learn about vision and 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 interest in science.