

## Using Light (Sunlight, Blue Light & Red Light) to Optimize Health | Huberman Lab Podcast #68

I describe the mechanisms by which different wavelengths of light impact the cells, tissues and organs of the human body, and how specifically timed light exposure of specific wavelengths can be used to improve sleep, enhance alertness, modulate hormone levels, and improve mood. I also explain the use of ultraviolet and infrared phototherapies to relieve pain increase testosterone and estrogen levels; improve skin health, appearance and wound healing; and how red light can be used to offset age-related vision loss and provide neuroprotection. Throughout the episode, I describe the mechanisms of light-based therapies and actionable tools that people can use positively impact mental and physical health.

Thank you to our sponsors

AG1 (Athletic Greens): <https://athleticgreens.com/huberman>

Thesis: <https://takethesis.com/huberman>

LMNT: <https://drinklmnt.com/huberman>

Our Patreon page

<https://www.patreon.com/andrewhuberman>

Supplements from Thorne

<https://www.thorne.com/u/huberman>

Social & Website:

Instagram - <https://www.instagram.com/hubermanlab>

Twitter - <https://twitter.com/hubermanlab>

Facebook - <https://www.facebook.com/hubermanlab>

TikTok - <https://www.tiktok.com/@hubermanlab>

Website - <https://hubermanlab.com>

Newsletter - <https://hubermanlab.com/neural-network>

Subscribe to the Huberman Lab Podcast:

Apple Podcasts: <https://apple.co/3DbFdlv>

Spotify: <https://spoti.fi/34Xod5H>

Google Podcasts: <https://bit.ly/3wo01EJ>

Other platforms: <https://hubermanlab.com/follow>

#### Article Links

Skin exposure to UVB light induces a skin-brain-gonad axis and sexual behavior:

<https://bit.ly/3MbtbeT>

Skin Exposure to Ultraviolet B Rapidly Activates Systemic Neuroendocrine and Immunosuppressive Response: <https://bit.ly/36nmojd>

A visual circuit related to the periaqueductal gray area for the antinociceptive effects of bright light treatment: <https://bit.ly/3xutcXo>

Light exposure during sleep impairs cardiometabolic function: <https://bit.ly/3xykAPq>

Light-emitting diodes in dermatology: A systematic review of randomized controlled trials: <https://bit.ly/3viUIJW>

Low-level laser (light) therapy (LLLT) in skin: stimulating, healing, restoring:

<https://bit.ly/3vwHJPQ>

Weeklong improved colour contrasts sensitivity after single 670 nm exposures associated with enhanced mitochondrial function: <https://go.nature.com/3rA6ljT>

Red light: A novel, non-pharmacological intervention to promote alertness in shift workers: <https://bit.ly/3MfBbvl>

Gamma Entrainment Binds Higher-Order Brain Regions and Offers Neuroprotection:

<https://bit.ly/3vqkgzB>

#### Other Links

Light pads: <https://amzn.to/3xAFVlb>

Light boxes: <https://amzn.to/36IHcaC>

#### Timestamps

00:00:00 Using Light to Improve Health

00:04:31 The Brain-Body Contract

00:05:17 AG1 (Athletic Greens), Thesis, LMNT

00:09:56 Physics of Light, Electromagnetic Energy

00:12:23 Wavelengths of Light

00:15:38 How Light Penetrates Tissues

00:20:13 Light & the Body: Direct & Indirect Signals  
00:28:35 Light, Seasonality & Melatonin  
00:33:40 Melatonin: Regulatory & Protective Effects  
00:38:49 Tools: Optimizing Melatonin Levels  
00:44:49 Sun (UVB light) Exposure, Mating Behavior, Testosterone & Estrogen  
00:58:09 Seasonality, Romantic Passion & Testosterone  
01:02:13 Tool: Skin Sun Exposure & Testosterone  
01:06:13 Light & Improved Pain Tolerance  
01:11:55 Protocol: Sun Exposure & Chronic Pain  
01:12:48 Tools: Sunlight (UVB), Blue-Light Blockers, Seasonal Affective Disorder (SAD)  
01:19:44 Light & Enhanced Immune Function  
01:23:30 Tool: Light During Winter Months  
01:26:18 Light Therapies: Local vs. Systemic Exposure  
01:28:54 Tool: Improving Mood, Timing of Natural & Artificial Light  
01:32:44 Light Conditions & Sleep Optimization  
01:39:00 Infrared Light, Skin & Wound Healing  
01:46:00 Infrared Light Therapy & Skin, Low-Level Laser (Light) Therapy (LLLT)  
01:49:20 Infrared Light & Age-Related Vision Loss  
01:59:36 Tools: Infrared Panels, Morning Exposure  
02:05:22 Infrared Light at Night, Shift Work  
02:08:35 Light Flicker Phototherapy & Neuroprotection  
02:19:07 Phototherapies for Health  
02:20:50 Zero-Cost Support, YouTube Feedback, Spotify Reviews, Apple Reviews, Sponsors, Patreon, Thorne, Instagram, Twitter, Neural Network Newsletter, Brain-Body Contract

The Huberman Lab Podcast is for general informational purposes only and does not constitute the practice of medicine, nursing or other professional health care services, including the giving of medical advice, and no doctor/patient relationship is formed. The use of information on this podcast or materials linked from this podcast is at the user's own risk. The content of this podcast is not intended to be a substitute for professional medical advice, diagnosis, or treatment. Users should not disregard or delay in obtaining medical advice for any medical condition they may have and should seek the assistance of their health care professionals for any such conditions.

Title Card Photo Credit: Mike Blabac - <https://www.blabacphoto.com>

- Welcome to the Huberman Lab Podcast, where we discuss science and science-based tools for everyday life. I'm Andrew Huberman, and I'm a professor of neurobiology and ophthalmology at Stanford School of Medicine. Today, we are going to discuss light and the many powerful uses of light to optimize our health. We're going to discuss the use of light for optimizing skin health, appearance, and longevity, for wound healing, for optimizing hormone balance, and for regulating sleep, alertness, mood, and even for offsetting dementia. One of the reasons why light has such powerful effects on so many different aspects of our biology is that it can be translated into electrical signals in our brain and body, into hormone signals in our brain and body, and indeed into what we call cascades of biological pathways, meaning light can actually change the genes that the cells of your bodies express. And that is true throughout the lifespan. Today, I will discuss the mechanisms by which all of that occurs. I promise to make it clear for those of you that don't have a biology background. And if you do have a biology background, I'll try and provide sufficient depth so that it's still of interest to you. And I promise to give you tools, very specific protocols that are extracted from the peer-reviewed literature that will allow you to use different so-called wave lengths, which most of us think of as colors, of light in order to modulate your health in the ways that are most important to you. For those of you that are thinking that the use of light to modulate health falls under the category of woo science, pseudoscience, or biohacking, well, nothing could be further from the truth. In fact, in 1903, the Nobel Prize was given to Niels Finsen, he was Icelandic, he lived in Denmark, for the use of phototherapy for the treatment of lupus. So there's more than a hundred years of quality science emphasizing the use of light, and as you'll soon see, the use of particular wavelengths or colors of light in order to modulate the activity of cells in the brain and body. So while it is the case that many places and companies are selling therapies and products related to the use of flashing lights and colored lights, promising specific outcomes from everything from stem cell renewal to improvement of brain function, and some of those don't have any basis in science, there are photo therapies that do have a strong foundation in quality science, and those are the studies and the protocols that we are going to discuss today. But I thought that people might appreciate knowing that over a hundred years ago, people were thinking about the use of light for the treatment of various diseases and for

improving health. And indeed many of those therapies are used today in high quality hospitals and research institutions and, of course, clinics and homes around the world. One of the more exciting examples of phototherapy in the last few years is the beautiful work of Dr. Glen Jeffery at University College London. The Jeffery Lab is known for doing pioneering and very rigorous research in the realm of visual neuroscience. And in the last decade or so, they turned their attention to exploring the role of red light therapy for offsetting age-related vision loss. What they discovered is that just brief exposures to red light early in the day can offset much of the vision loss that occurs in people 40 years or older. And what's remarkable about these studies is that the entire duration of the therapy is just one to three minutes, done just a few times per week. What's even more exciting is that they understand the mechanism by which this occurred. The cells in the back of the eye that convert light information into electrical signals that the rest of the brain can understand and create visual images from, well, those cells are extremely metabolically active. They need a lot of ATP or energy. And as we age, those cells get less efficient at creating that ATP and energy. Exposure to red light early in the day, and it does have to be early in the day, allowed those cells to replenish the mechanisms by which they create ATP. I'll talk about these experiments in more detail later in the episode and the protocols so that you could apply those protocols should you choose. But I use this as an example of our growing understanding of not just that phototherapies work but how they work. And it is through the linking of protocols and mechanism

00:04:31 The Brain-Body Contract

that we, meaning all of us, can start to apply phototherapies in a rational, safe, and powerful way. I'm pleased to announce that I'm hosting two live events this May. The first live event will be hosted in Seattle, Washington on May 17th. The second live event will be hosted in Portland, Oregon on May 18th. Both are part of a lecture series entitled The Brain Body Contract, during which I will discuss science and science-based tools for mental health, physical health, and performance. And I should point out that while some of the material I'll cover will overlap with information covered here on the Huberman Lab Podcast and on various social media posts, most of the information I will cover is going to be distinct from information covered on the podcast or elsewhere. So once again, it's Seattle on May 17th, Portland on May 18th.

00:05:17 AG1 (Athletic Greens), Thesis, LMNT

You can access tickets by going to [hubermanlab.com/tour](http://hubermanlab.com/tour). And I hope to see you there. Before we begin, I'd like to emphasize that this podcast is separate from my teaching and research roles at Stanford. It is, however, part of my desire and effort to bring zero cost to consumer information about science and science-related tools to the general public. In keeping with that theme, I'd like to thank the sponsors of today's podcast. Our first sponsor is Athletic Greens, also called AG1. I started taking AG1 way back in 2012, so I'm delighted that they're sponsoring the podcast. The reason I started taking AG1 and the reason I still take AG1 once or twice a day is that it covers my foundational vitamin, mineral, and probiotic needs. It also has adaptogens and things like zinc for immune system function, but the probiotics are one of the key features in there. I've done several podcasts on the gut microbiome, which are these trillions of microbiota that live in our digestive tract, and that are crucial for our immune system, brain function, and so on. One way to enhance our gut microbiome to ensure that it's healthy is to make sure that we get the correct probiotics. And Athletic Greens has the correct prebiotics and probiotics that ensure a healthy gut microbiome. If you'd like to try Athletic Greens, you can go to [athleticgreens.com/huberman](http://athleticgreens.com/huberman) to claim a special offer. They'll give you five free travel packs that make it very easy to mix up Athletic Greens while you're on the road, so in the car and on the plane. I should mention the Athletic Greens is delicious. I love the way it tastes. I mix mine with some water and a little bit of lemon or lime juice. This special offer is the five free travel packs plus a year's supply of vitamin D3+K2. Vitamin D3 has been shown to be important for a tremendous number of biological functions. Many of us who get sunlight get enough vitamin D3. Many of us, even if we do get sunlight, do not get enough Vitamin D3. So the year's supply of vitamin D3 also has K2, which is important for cardiovascular function for calcium regulation. Again, go to [athleticgreens.com/huberman](http://athleticgreens.com/huberman) to get the five free travel packs and the year's supply of vitamin D3+K2. Today's episode is also brought to us by Thesis. Thesis makes custom nootropics. Nootropic is a smart drug. And personally, I'm not a big fan of the concept of a smart drug, at least not the way that most people talk about smart drugs or nootropics, for the following reason. Being smart involves various things. There is creativity, there's focus, there's task switching, and so on. And each one of those involves different operations in the brain. Different neural circuits, different neurochemicals have to be deployed in order for us to, for instance, be very focused or for us to be very creative or

for us to be able to switch tasks easily. Thesis understands this. And for that reason, they've developed custom nootropics that are aimed at getting your brain and body into particular states for particular types of work or physical activity. In order to accomplish that, they've created unique blends of high quality ingredients. And each of those blends is designed to get your brain and body into a particular mode, such as focus, clarity, or motivation. I've been using Thesis nootropics for over six months now. And I have to say it's been a total game changer and very unique from the experience of using sort of what I call catchall nootropics. So with Thesis, it's really directed toward particular brain-body states. I should also mention that they tailor those custom blends to you. So by taking a quiz on their site, they will tailor the blend to you and your specific needs and the things you don't want. So if you want to try your own personalized nootropic starter kit, you can go online to [takethesis.com/huberman](https://takethesis.com/huberman). You'll take a three-minute quiz, and Thesis will send you four different formulas to try in your first month. And then based on the outcomes with those, they can update your formulations for you. That's [takethesis.com/huberman](https://takethesis.com/huberman) and use the code Huberman at checkout to get 10% off your first box. Today's episode is also brought to us by LMNT. LMNT is a properly balanced electrolyte drink that has no sugar. When we get our electrolytes in the proper ratios, the cells of our brain and body can function optimally. Many people are surprised to find that when they increase their sodium intake, provided that it is a proper balance with potassium and magnesium, they can think more clearly, they recover from exercise better, and they have more energy. There is no surprise as to how that all works, however. Every cell of your body requires the electrolytes to function. And in particular, the neurons of your brain and body require sodium in order to function. So while people with pre-hypertension and hypertension definitely need to be careful about increasing their sodium intake, many people do well to increase their sodium intake, again, provided it's in the proper balance with potassium and magnesium. LMNT provides that proper balance. If you'd like to try LMNT, you can go to [drinklmnt.com/huberman](https://drinklmnt.com/huberman) to claim a free LMNT sample pack. You only cover the cost of shipping.

00:09:56 Physics of Light, Electromagnetic Energy

Again, that's [drinklmnt.com/huberman](https://drinklmnt.com/huberman) to claim a free sample pack. Okay, let's talk about light. First, I want to talk about the physics of light, and I promise to make that very clear, even if you don't have a background in physics. And then I want to talk about

the biology of light, meaning how light is converted into signals that your brain and body can use to impact things like organ health or disease, or how it can use light in order to repair particular organs, like your skin, your eyes, your brain, et cetera. The physics of light can be made very simple by just illustrating a few key bullet points. The first bullet point is that light is electromagnetic energy. If the word electromagnetic feels daunting to you, well, then just discard that and just think of light as energy and think of energy as something that can impact other things in its environment. Now, the way to imagine light or to conceptualize light as energy is that all around you light is traveling in these little wavelengths. And the reason, for those of you that are watching, I'm making a little wavy motion with my hand is that's actually the way that light energy moves in little waves. Just like sound waves are coming at you and impinging on your ears, if you can hear me talking right now, that is happening, those are sound waves, meaning the movement of air particles out there impacting your ear drum. Well, light energy is just little bits of electromagnetic energy traveling through your environment all the time in these little waves and impinging on your brain and body and eyes, et cetera. And as I mentioned before, energy can change the way that other things behave. It can cause reactions in cells of your body. It can cause reactions in fruit, for instance, right? You see a piece of fruit and it's not ripe, but it gets a lot of sunlight and it ripens. That's because the electromagnetic energy of sunlight had an impact on that plant or that tree, or even on the fruit directly. As a parallel example of energy and its ability to impact other things, we are all familiar with food and the fact that food has calories. Calorie is a measure of energy. It has everything to do with how much heat is generated when you burn a particular article of food, believe it or not. And it turns out that how hot a given article of food burns gives you a sense of how much energy it can provide your body in terms of your body's ability to store or use that energy. So again, think of light as electromagnetic energy,

00:12:23 Wavelengths of Light

but really put that word energy into capital letters, embed that in your mind, going forward, and you'll understand most of the first bullet point of what light is in terms of the physics of light. Now, the second thing that you need to understand about the physics of light is that light has many different wavelengths, and the simplest way to conceptualize this is to imagine that cover of that Pink Floyd album, where there's a prism. You have a



white beam of light going into that prism. And then the prism splits that beam of light into what looks like a rainbow. So you got your reds, your orange, your greens, your blues, your purples, et cetera. Anytime we have light in our environment, that is so-called white light. It includes all those wavelengths, but sunlight and other forms of light also have other wavelengths of light that we can't see. So when we think about the rainbow, that's just the visible spectrum of light. There are also wavelengths of light that are not visible to us, but that are visible to some other animals, and that can still impact your brain and body because there is still energy at those wavelengths. I'll give a few examples of this. Humans are not a species that can see into the infrared realm of the spectrum. A pit viper, meaning a snake that has infrared sensors, however, can sense in the infrared. So if you were to walk through a jungle and there's a pit viper there, it sees you as a cloud of heat emission because your body is emitting infrared energy all the time. You're casting off infrared energy. The snake can see it, you can't. If you were to put on a particular set of goggles that were infrared goggles, well, then you would be able to see the heat emissions of any organism, human or otherwise, that could emit infrared energy. Let's take the opposite end of the spectrum. We are familiar with seeing things that are blue or green or very pale blue. But as we say below that, meaning even shorter wavelength light is out there. Ultraviolet light is a really good example of light energy that's coming from the sun and is in our environment and is being reflected off surfaces all the time. We don't see it. And yet, if it's very bright outside, that ultraviolet light can burn our skin. As you'll learn in today's episode, ultraviolet light can also positively impact us. In fact, I will describe a particular set of new results that show that ultraviolet light viewed for just a few minutes each day, or landing on the skin for just a few minutes each day, can actually offset a lot of pain. It actually has the ability to reduce the amount of pain sensed by your body. And we now understand the specific circuits in the brain and body that allow that to happen. I'll talk about that and the related protocols a little bit later. So the important thing to understand about the physics of light is that there's energy at all these different wavelengths. We only see some of those wavelengths, which basically is to say that light impacts us at many different levels. And the so-called levels that I'm referring to are the different wavelengths of light. And you're welcome to think of the different wavelengths of light as different colors, but do understand that there are truly colors of light

00:15:38 How Light Penetrates Tissues

that you and I can't see, and yet that have powerful impact on your brain and body. Now, the third bullet point to understand about the physics of light is that different wavelengths of light, because of the way that their wave travels, can penetrate tissues to different depths. This is very, very important. Today, we're going to talk a lot about red light therapies and near-infrared light therapies. Those are so called longer wavelengths. Longer wavelengths, just think of a bigger, longer wave, right? A bigger curve, as opposed to short wavelength light, which is going to be shorter, right? A short wavelength light would be something like blue or green light or ultraviolet light. Blue, green, and ultraviolet light, because its shortwave length light, doesn't tend to penetrate tissues very easily. It has to do with the way that the physics of light interacts with the physical properties of your skin and other tissues of your body. But basically, if you were to shine UV light onto your arm, for instance, it could impact the skin on the surface of the arm, maybe some of the cells just beneath the top layer of skin, but it wouldn't penetrate much deeper. Long wavelength light like red light and near-infrared light has this amazing ability to penetrate through tissues, including your skin. And so if we were to shine red light or near-infrared light onto your arm, it would pass through that top layer of skin. It might impact it a little bit, but it could penetrate deeper into your skin, not just to the skin layers, but maybe even down to the bone, maybe even down to the bone marrow. And for many people, this will be hard to conceptualize. You think, "Well, wait, I've got the skin there. Doesn't the light just bounce off?" And the answer is no, because of the way that long wavelength light interacts with the absorbance properties of your skin. Absorbance properties are just the way that the skin takes light energy and converts it into a different form of energy. And your skin is not able to take long wavelength light, like red light and near-infrared light, and absorb it. But the tissues deeper in your body can. So if you shine a red light or near-infrared light onto the surface of your skin, you'll see a red glow there as a reflectance on the surface of your skin. But a lot of the photon energy, the light energy in those longer wavelengths is indeed passing through those top layers of skin, into the deeper layers of skin, and can even make it into the deep layers of your arm. And as we start to transition from the physics of light to the biological impacts of light, just understanding that the different wavelengths of light impact our tissues at different levels, literally at different depths, will help you better understand how light of different colors, of different intensities and how long you are exposed to those colors and intensities of light can change the way that the cells and the

organs of your body work. And if it didn't sound weird enough that you can pass light through particular tissues and have them land and be absorbed at tissues deeper in your body, well, it turns out that different wavelengths of light are also best absorbed by particular so-called organelles within your cells. What are organelles? Organelles are the different compartments and different functions within a given cell. So for instance, your mitochondria, which are responsible for generating ATP and energy in your cells, those exist at a particular depth, at a particular location within a cell. They're not all at the cell surface. They sit somewhat deeper in the cell. The nucleus of your individual cells contains DNA, and that sits at a particular depth or location within your cell. Different wavelengths of light not only can penetrate down into different tissues and into different cells of your body, but they can also penetrate and access particular organelles, meaning mitochondria or the nucleus or the different aspects of your cells that are responsible for different functions. This is exquisitely important, and it's exquisitely powerful because as you'll learn today, particular wavelengths of light can be used to stimulate the function of particular organelles within particular cells, within particular organs of your body. I can think of no other form of energy, not sound, not chemical energy, so not drugs, not food, not touch, no form of energy that can target the particular locations in our cells, in our organelles, in our organs and in our body, to the extent that light can. In other words, if you had to imagine a real world surgical tool by which to modulate our biology,

#### 00:20:13 Light & the Body: Direct & Indirect Signals

light would be the sharpest and the most precise of those tools. Now, let's talk about how light is converted into biological signals. There's several ways in which that is accomplished, but the fundamental thing to understand is this notion of absorption of light energy. Certain pigments or colors in the thing that is receiving the light energy, meaning the thing that the light energy lands on, are going to absorb particular wavelengths of light. Now, I promise you that you already intuitively know how this works. For instance, if you were to sit outside on a very bright sunny day, and you had a table in front of you that was metal, you might find it hard to look down at that metal table because it's reflecting a lot of light of particular wavelengths. If that table were pitch black, however, it wouldn't reflect quite as much, and you would be able to comfortably look at it. If that table were red, it might be somewhere in between. If that table were

green, it would be also somewhere in between, but let's say it were very light blue. Well, then it might reflect almost as much as a table that were just metal or a white table surface. So the absorbance properties of a given surface will determine whether or not light energy goes and stays at that location and has an impact on that location or whether or not it bounces off. Every biological function of light has to do with the absorbance or the reflectance of light or light passing through that particular thing, meaning that particular cell or compartment within a cell. I'd like to make it clear how this works by using the three primary examples of how you take light in your environment and convert it into biological events. We have photoreceptors in the back of our eyes. These photoreceptors come in two major types, the so-called rods and the cones. The rods are very elongated, they look like rods. And the cones look like little triangles. Rods and cones have within them photopigment. They have dark stuff that's stacked up in little layers. Rods absorb light of essentially any wavelength. There's some variation to that, but let's just say rods don't care about the different colors of light. They will absorb light energy, photon energy, if it's red, if it's green, if it's blue, if it's yellow, doesn't matter, as long as that light is bright enough. And it turns out that rods are very, very sensitive. They can detect very, very small numbers of photons. And rods are essentially what you use to see in very low light conditions. We'll return more to vision later. The cones come in three major varieties. At least for most people who aren't colorblind, you have so-called red cones, green cones, and blue cones. But they're not really red, green, and blue in the back of your eye. They are cones that either absorb long wavelength light, red, that absorb medium wavelength light, green, or short wavelength light, blue. The reason that they can absorb different wavelengths of light is they have different photopigments. So much as the example I gave before, where you have different tables outside in the sunny environment, and some are reflecting light more than others, others are absorbing light more than others, well, so too, the photoreceptors, meaning the cones, are absorbing light of different wavelengths to different extents. And in an absolutely incredible way, your brain is actually able to take that information and create this perception that we have of color. But that's another story altogether that we'll just touch on a little bit more later, but that if you want to learn all about, you can go to our episode on vision. So that's photoreceptors in the back of your eye, absorbing light of different wavelengths, rods, and cones. The other place, of course, where light can impact our body is on our surface, on our skin. And skin has pigment too. We call that pigment melanin. We have within our skin multiple cell types, but in the top layer of skin,

which is called the epidermis, we have keratinocytes, and we have melanocytes. And the melanocytes are the cells that create pigmentation of the skin. And of course there is wide variation in the degree to which there is pigmentation of the skin, which has to do with genetics, also has to do with where you were born and raised, how much light exposure you have throughout the year, right? So people toward the equator tend to have more melanocyte activity than people who are located at the North Pole. And of course, people live at different locations throughout the Earth, regardless of their genetic background or where they were born. And so, as you all know, with light exposure, those melanocytes will turn on genetic programs and other biological programs that lead to enhanced pigmentation of the skin, which we call tanning. The way they do that is by absorbing UV light specifically. So with melanocytes, we have a very specific example of how a pigment absorbs light of a particular length, in this case, ultraviolet shortwave length light, which in turn creates a set of biological signals within those cells that in turn creates changes in our skin pigmentation. So we have photoreceptors, we have melanocytes. And the third example I'd like to provide is that of every cell of your body. And what I mean by that is that every cell of your body, meaning a cell that is part of your bone tissue or your bone marrow or heart tissue or liver or spleen, if light can access those cells, it will change the way that those cells function for better or for worse. For many organs within our body that reside deep to our skin, light never arrives at those cells. A really good example of this that we'll touch on later is the spleen. Unless you have massive damage to your body surface, unless you literally have a hole in your body, light will never land directly on your spleen, but the spleen still responds to light information through indirect pathways. And those indirect pathways arise through light arriving on the skin and light arriving on the eyes. So a key principle that I'm going to return to again and again today is that the ways in which light can impact the biology of your organelles, your cells, your organs, and the tissues, and indeed your whole body, can either be direct, so for instance, light onto your skin impacting skin or light onto your photoreceptors impacting the photoreceptors of your eye, or it can be indirect. It can be light arriving on your photoreceptors, the photoreceptors then informing another cell type, which informs another cell type, which then relays a signal in kind of a bucket brigade manner off to the spleen and says to the spleen, "Hey, there's a lot of UV light out here. We're actually under stress. In fact, there's so much UV light that you need to activate an immune program to protect the skin." And in response to that, the spleen can deploy certain signals in certain cell types to go out and start repairing skin that's being

damaged by UV light. So we have direct signals and we have indirect signals, but in every case, it starts with light of particular wavelengths being absorbed by particular pigments or properties of the surfaces that those light waves land on. And as you recall from our discussion about the physics of light, remember, it's not just about light impinging on the surface of your body. Light can actually penetrate deep to the skin and access at least certain tissues and cells of your body. Even though you can't see those wavelengths of light, they are getting into you all the time. So perhaps the best way to wrap this discussion about the physics and the biology of light with a bit of a bow is to think about light as a transducer, meaning a communicator of what's going on in the environment around you and that some of those signals are arriving at the surface and impacting the surface of your body. But many of those signals are being taken by cells at the surface of your body, meaning your melanocytes in your skin and the photoreceptors of your eyes,

00:28:35 Light, Seasonality & Melatonin

and then being passed off as a set of instructions to the other organs and tissues of your body. Light can impact our biology in very fast, moderately fast, and slow ways. But even the slow ways in which light can impact our biology can be very powerful and very long-lasting. Just as a quick example of the rapid effects of light on our biology, if you were to go from a room that is dimly lit or dark into a very brightly lit room, you would immediately feel very alert. You might say, "No, that's not true. Sometimes I wake up and it's dark, and I kind of stumble out and it's lighter out in the next room. And it takes me a while to wake up." Ah, but if we were to move you from a room that was very dark to very bright, a signal conveyed from your eyes to an area of your brain stem called the locus coeruleus would cause the release of adrenaline similar to the release of adrenaline if you were to be dropped into very, very cold water all of a sudden. Just an immediate wake-up signal to your brain and body. So that's an example of a rapid effect of light on your biology, not a very typical one, but nonetheless, one that has a hardwired biological mechanism. At the other end of the spectrum are what we call slow integrating effects of light on our biology. So what I mean by that are ways in which your body is taking information about light in the environment, not in the sort of snapshot, acute sense, but averaging the amount of light in your environment. And that average light information is changing the way that your biology works. But even though this is a slow

process, as I mentioned before, it's a very powerful one. The primary example of this are so-called circannual rhythms. Circannual rhythms are literally a calendar that exists within your body that uses not numbers, but amounts of hormone that are released into your brain and body each day and each night as a way of knowing where you are in the 365-day calendar year. Now that might seem kind of crazy, but it's not crazy. The Earth travels around the sun once every 365 days. And depending on where you are on the Earth, where you live, you are going to get more or less light each day on average, depending on the time of year. So if you're in the Northern Hemisphere, in the winter months, days are shorter, nights are longer. In the summer months, days are longer, nights are shorter. And of course, things change whether or not you're in the Northern Hemisphere or the Southern Hemisphere, but nonetheless in short days you have more darkness, that's obvious. And if you understand that light arriving on the eyes is absorbed by a particular cell type called the intrinsically photosensitive ganglion cell. It's just a name. You don't need to know the name, but if you want, it's the so-called intrinsically photosensitive ganglion cell, also called the melanopsin cell because it contains an opsin, a photopigment that absorbs shortwave length light that arrives through sunlight. Those cells communicate to particular stations in the brain that in turn connect to your so-called pineal gland, which is this little pea-sized gland in the middle of your brain that releases a hormone called melatonin. And the only thing you need to know is that light activates these particular cells, the intrinsically photosensitive melanopsin cells, which in turn shuts down the production of melatonin from the pineal gland. If you think about this in terms of the travel of the Earth around the sun across the year, what it means is that in short days, because there's very little light on average landing on these cells, the duration of melatonin release will be much longer because as I mentioned before, light inhibits, it shuts down melatonin. Whereas in the summer months, much more light on average will land on your eyes, right? Because days are longer. Even if you're spending more time indoors, on average, you're going to get more light to activate these cells. And because light shuts down melatonin production, what you'll find is that the duration of melatonin release for the pineal is much shorter. So melatonin is a transducer. It's a communicator of how much light on average is in your physical environment. What this means is for people living in the Northern Hemisphere, you're getting more melatonin release in the winter months than you are in the summer months. So you have a calendar system that is based in a hormone, and that hormone is using light in order to determine where you are in that journey around the sun. Now, this

is beautiful. At least to me, it's beautiful because what it means is that the environment around us is converted into a signal

#### 00:33:40 Melatonin: Regulatory & Protective Effects

that changes the environment within us. That signal is melatonin, and melatonin is well known for its role in making us sleepy each night and allowing us to fall asleep. Many of you have probably heard before, I am not a big fan of melatonin supplementation for a number of reasons, but just as a quick aside, the levels of melatonin that are in most supplements are far too high to really be considered physiological. They are indeed super physiological in most cases, and melatonin can have a number of different effects, not just related to sleep, but that's supplemented melatonin. Here, I'm talking about our natural production and release of melatonin according to where we are in the 365-day calendar year. Endogenous melatonin, meaning the melatonin that we make within our bodies naturally, not melatonin that's supplemented, has two general categories of effects. The first set of effects are so called regulatory effects and the others are protective effects. The regulatory effects are for instance, that melatonin can positively impact bone mass. So melatonin can, for instance, turn on the production of osteoblasts, which are essentially stem cells that make more bone for us that make our bones stronger and that can replace damaged aspects of our bone. Melatonin is also involved in maturation of the gonads during puberty, the ovaries and the testes. Although there, the effects of melatonin tend to be suppressive on maturation of the ovaries and testes, meaning high levels of melatonin tend to reduce testicle volume and reduce certain functions within the testes, including sperm production and testosterone production. And within the ovaries, melatonin can suppress the maturation of eggs, et cetera. Now, I don't want anyone to get scared if you've been taking melatonin. Most of the effects of melatonin on those functions are reversible, but I should point out that one of the reasons why children don't go into puberty until a particular age is that young children tend to have chronically high endogenous melatonin. And that is healthy to keep them out of puberty until it's the right time for puberty to happen. So melatonin can increase bone mass, but reduces gonad mass, so to speak. It's going to have varying effects depending on the ratios and levels of other hormones and other biological events in the body. But as you can see, melatonin has these powerful regulatory on other tissues. I should also mention that melatonin is a powerful modulator of placental development. So



for anyone that's pregnant, if you're considering melatonin supplementation, please, please, please talk to your OB/GYN, talk to your other doctor as well. You want to be very, very cautious because of the powerful effects that melatonin can have on the developing fetus and placenta. For people that are not pregnant, in fact, all people, melatonin has a powerful effect on the central nervous system as a whole. Your brain and spinal cord are the major components of your central nervous system, and melatonin, because it's associated with darkness, which is just another way of saying that light suppresses melatonin, melatonin is thereby associated with the dark phase of each 24-hour cycle, it can have a number of different effects in terms of waking up or making our body feel more sleepy. And it does that by way of impacting cells within our nervous system, literally turning on certain brain areas, turning off other brain areas. And it does that through a whole cascade of biological mechanisms, a bit too detailed to get into today. So melatonin is regulating how awake or asleep we are. It tends to make us more asleep, incidentally. It's regulating our timing of puberty, and it's regulating how our gonads, the testes and ovaries, function, even in adulthood, to some extent. And it's regulating bone mass. As I mentioned before, melatonin also has protective effects. It can activate our immune system. It is among the most potent antioxidants. So it is known to have certain anti-cancer properties and things of that sort, which is not to say that you simply want more melatonin. I think a lot of people get misled when they hear something like, melatonin has anti-cancer properties. That doesn't mean that cranking up the levels of melatonin by supplementing it, or by spending time in darkness and not getting any light, which would, of course, inhibit melatonin, is going to be beneficial for combating cancer. That's not the way it works. It is actually the rise and fall of melatonin every 24-hour cycle and the changes in the duration of that melatonin signal throughout the seasons that has these anti-cancer and antioxidant effects. So when we think about light impacting our biology, the reason I bring up melatonin as the primary example of that is A, because melatonin impacts so many important functions within our brain and body, but also because hormones in general, not always, but in general, are responsible for these slow modulatory effects on our biology. And so I'm using this as an example of how light throughout the year is changing the way that the different cells and tissues and organs of your body are working, and that melatonin is the transducer of that signal. So at this point, we can say light powerfully modulates melatonin, meaning it shuts down melatonin. Melatonin is both beneficial for certain tissues

## 00:38:49 Tools: Optimizing Melatonin Levels

and suppressive for other tissues and functions. What should we do with this information? Well, it's very well established now that one of the best things that we can all do is to get the proper amount of sunlight each day. And by proper, I mean appropriate for that time of year. So in the summer months where the days are longer and nights are shorter, we would all do well to get more sunlight in our eyes. And again, it's going to be to our eyes because as you recall, the pineal sits deep in the brain, and light can't access the pineal directly, at least not in humans. So in order to get light information to the pineal and thereby get the proper levels of melatonin according to the time of year, we should all try and get outside as much as possible during the long days of summer and spring. And in the winter months, it makes sense to spend more time indoors. For those of you that suffer from seasonal affective disorder, which is a seasonal depression, or feel low during the fall and winter months, there are ways to offset this. We did an entire episode on mood and circadian rhythms where we described this. So it does make sense for some people to get more bright light in their eyes early in the morning and throughout the day during the winter months as well. But nonetheless, changes in melatonin, meaning changes in the duration of melatonin release across the year are normal and healthy. So provided that you're not suffering from depression, it's going to be healthy to somewhat modulate your amount of indoor and outdoor time across the year. The other thing to understand is this very firmly established fact, which is light powerfully inhibits melatonin. If you wake up in the middle of the night, and you go into the bathroom and you flip on the lights, and those are very bright, overhead, fluorescent lights, your melatonin levels, which would ordinarily be quite high in the middle of the night because you've been eyes closed in the dark, presumably, will immediately plummet to near zero or zero. We would all do well regardless of time of year to not destroy our melatonin in the middle of the night in this way. So if you need to get up in the middle of the night and use the restroom, which is a perfectly normal behavior for many people, use the minimum amount of light required in order to safely move through the environment that you need to move through. Melatonin needs to come on early in the night. It actually starts rising in the evening and towards sleep. But then as you close your eyes and you go to sleep, melatonin levels are going to continue to rise at least for several hours into the night. Again, if you get up in the middle of the night, really try hard not to flip on a lot of bright lights. If you do that every

once in a while, it's not going to be a problem. But if you're doing that night after night, you are really disrupting this fundamental signal that occurs every night, regardless of winter, spring, summer, et cetera. And that is communicating information about where your brain and body should be in time. And I know that's a little bit of a tricky concept, but really our body is not meant to function in the same way during the winter months, as the summer months. There are functions that are specifically optimal for the shorter days of winter. And there are functions that are specifically optimal for the longer or days of summer. So again, try to avoid bright light exposure to your eyes in the middle of the night. And for those of you that are doing shift work, what I can say is try and avoid getting bright light in your eyes in the middle of your sleep cycle. So even if you're sleeping in the middle of the day, because you have to work at night, if you wake up during that about of sleep, really try hard to limit the amount of light, which is going to be harder for shift workers, right? Because there are generally a lot more lights on and bright lights outside, so you would want to close the blinds and limit artificial light inside. One way to bypass some of the inhibitory effects of light on melatonin is to change your physical environment by, for instance, dimming the lights. That's one simple way, very low-cost way. In fact, you'll save money by dimming the lights or turning them off. The other is if you are going to use light, using long wavelength light, because, as you recall, these intrinsically photosensitive melanopsin cells within your retina that convey the signal about bright light in your environment to impact melatonin, to shut down melatonin, respond to short wavelengths of light. So red light is long wavelength light. You now understand that from our discussion about the physics of light. And if you were to use amber-colored light or red light and even better, dim amber or dim red light in the middle of the night, well, then you would probably not reduce melatonin at all unless those red lights and amber lights are very, very bright. Any light, provided it's bright enough, will shut down melatonin production. One final point about melatonin, and this relates to melatonin supplementation as well, is that now that you understand how potently melatonin can impact things like cardiovascular function, immune function, anti-cancer properties, bone mass, gonad function, et cetera, you can understand why it would make sense to be cautious about melatonin supplementation, because supplementation tends to be pretty static. It's X number of milligrams per night, whereas normally endogenously the amount of melatonin that you're releasing each night is changing according to time of year, or if you happen to live in an area where there isn't much change in day length across the year, so for instance, if you live near the equator,

well, then your body is accustomed to having regular amounts of melatonin each night. When you start supplementing melatonin, you start changing the total amount of melatonin, obviously, but you're also changing the normal rhythms in how much melatonin is being released into your brain and body across the 365-day calendar year. So while I'm somebody who readily embraces supplementation in various forms, for things like sleep and focus, et cetera, when it comes to melatonin, I'm extremely cautious. And I think it's also one of the few examples where a hormone is available without prescription, over the counter. You just go into a pharmacy or drugstore or order online, this hormone, which is known to have all these powerful effects. So I get very, very concerned when I hear about people taking melatonin,

00:44:49 Sun (UVB light) Exposure, Mating Behavior, Testosterone & Estrogen

especially at the levels that are present in most supplements. It's been recognized for a very long time, and in fact, there are now data to support the fact that animals of all kinds, including humans, will seek out mates and engage in mating behavior more frequently during the long days of spring and summer. That's right, in seasonally-breeding animals, of course, this is the case, but in humans as well, there is more seeking out of mates and mating behavior in longer day times of year. Now, you could imagine at least two mechanisms by which this occurs. The first mechanism we could easily map to melatonin and the fact that melatonin is suppressive to various aspects of the so-called gonadal axis, which is basically a fancy way of saying that melatonin inhibits testosterone and estrogen output from the testes and from the ovaries. I just want to remind people that both males and females make testosterone and estrogen, although in different ratios, typically, in males versus females, and that both testosterone and estrogen are critical for the desire to mate and for mating behavior. There's a broad misconception that testosterone is involved in mating behavior and estrogen's involved in other behaviors, but having enough estrogen is critical for both males and females in order to maintain the desire to mate, and indeed the ability to mate. I discuss this on the episode on optimizing testosterone and estrogen. So if you'd like more details on that, please see that episode of the Huberman Lab Podcast. Okay, so if melatonin is suppressive to the so-called gonadal axis and reduces overall levels of testosterone and estrogen in males and females and a light inhibits melatonin, then when there's more light, then there's less melatonin and more hormone output from the gonads. And indeed

that's how the system works, but that's not the entire story. It turns out that there is a second so-called parallel pathway, meaning a different biological pathway that operates in parallel to the light suppression of melatonin pathway that provides a basis for longer days, inspiring more desire to mate and more mating behavior. So if we think of the first pathway involving melatonin as sort of a break on these reproductive hormones, the second mechanism is more like an accelerator on those hormones. And yet it still involve light. As I'm about to tell you, in animals such as mice, but also in humans, exposure to light, in particular UV blue light, so short wavelengths of light, can trigger increases in testosterone and estrogen and the desire to mate. Now what's especially important about this accelerator on the desire to mate and mating behavior and hormones is that it is driven by exposure to light, but it is not the exposure of light to the eyes. It turns out that it is the exposure of your skin to particular wavelengths of light that is triggering increases in the hormones, testosterone, and estrogen, leading to increased desire to mate. As it turns out, your skin, which most of us just think of as a way to protect the organs of our body or something to hang clothes on or ornaments on, if you're somebody who has earrings and so forth, your skin is actually an endocrine organ, meaning it is a hormone-producing and hormone-influencing organ. I promise what I'm about to tell you next will forever change the way that you think about your skin and light and the desire to mate, and indeed even mating behavior. I think the results are best understood by simply going through the primary data, meaning the actual research on this topic. And to do so, I'm going to review a recent paper that was published in the Journal Cell Reports, Cell Press Journal, excellent journal. This is a paper that came out in 2021, entitled "Skin Exposure to UVB light induces a skin, brain, gonad axis, and sexual behavior. And I want to emphasize that this was a paper that focused on mice in order to address specific mechanisms, because in mice, you can so-called knock out particular genes. You can remove particular genes to understand mechanism. You just can't do that in humans in any kind of controlled way, at least not at this point in time. And this study also explores humans and looked at human subjects, both men and women. The basic finding of this study was that when mice or humans were exposed to UVB, meaning ultraviolet blue light, so shortwave length light of the sort that comes through in sunshine, but is also available through various artificial sources. If they received enough exposure of that light to their skin, there were increases in testosterone that were observed within a very brief period of time, also increases in the hormone estrogen. And I should point out that the proper ratios of estrogen and testosterone were

maintained in both males and females, at least as far as these data indicate, and mice tended to seek out mating more and mate more. There were also increases in gonadal weight, literally increases in testis size and in ovarian size when mice were exposed to this UVB light past a certain threshold. Now, as I mentioned before, the study also looked at humans. They did not look at testis size or ovarian size in the human subjects. However, because they're humans, they did address the psychology of these human beings and addressed whether or not they had increases in, for instance, aggressiveness or in passionate feelings and how their perception of other people changed when they were getting a lot of UVB light exposure to the skin. So before I get into some of the more important details of the study and how it was done and how you can leverage this information for yourself, if you desire, I just want to highlight some of the basic findings overall. UVB exposure increased these so-called sex steroid levels in mice and humans. The sex steroid hormones, when we say steroids, we don't mean anabolic steroids taken exogenously. I think when people hear the word steroids, they always think steroid abuse or use, rather. Steroid hormones, such as testosterone and estrogen, went up when mice or humans had a lot of UVB exposure to their skin. Second of all, UVB light exposure to the skin enhanced female attractiveness, so the perceived attractiveness of females by males, and increased the receptiveness or the desire to mate in both sexes. UVB light exposure also changed various aspects of female biology related to fertility, in particular follicle growth. Follicle and egg maturation are well-known indices of fertility, and of course, correlate with the menstrual cycle in adult humans and is related overall to the propensity to become pregnant. UVB light exposure enhanced maturation of the follicle, which just meant that more healthy eggs were being produced. These are impressive effects. First of all, they looked at a large number of variables in the study. And the fact that they looked at mice and humans is terrific. I think that oftentimes we find it hard to translate data from mice to humans. So the fact that they looked at both in parallel is wonderful. In the mice and in the humans, they established a protocol that essentially involved exposing the skin to UV light that was equivalent to about 20 to 30 minutes of midday sun exposure. Now, of course, where you live in the world will dictate whether or not that midday sun is very, very bright and intense or is less bright. Maybe there's cloud cover, et cetera. But since I'm imagining that most people are interested in the ways to increase testosterone and/or estrogen in humans and are not so much interested in increasing testosterone in mice, I'm going to just review what they did in the human population or the human subjects.

What they did is they had people, first of all, establish a baseline. And the way they established a baseline was a little bit unusual, but will make perfect sense to you. They had people wear long sleeves and essentially cover up and avoid sunlight for a few days so they could measure their baseline hormones in the absence of getting a lot of UVB light exposure from the sun or from other sources. Now, of course, these people had access to artificial lights, but as I've pointed out on this podcast before, it's pretty unusual that you'll get enough UVB exposure from artificial lights throughout the day. And in the morning you need a lot of UVB exposure, or we should be getting a lot of UVB exposure to our eyes and to our face and to our skin throughout the day, provided we're not getting sunburnt. This is actually a healthy thing for mood and for energy throughout the day. It's only at night, basically between the hours of about 10:00 pm and 4:00 am, that even a tiny bit of UVB exposure from artificial sources can mess us up in terms of our sleep and our energy levels, and so on. And that's because of the potent effect of UVB on suppressing melatonin. So the point here is that they establish a baseline whereby people were getting some artificial light exposure throughout the day, but they weren't getting outside a lot. They weren't getting a lot of sunlight. And then they had people receive a dose of UVB light exposure that was about 20 to 30 minutes outdoors. They had people wear short sleeves, no hat, no sunglasses. Some people wore sleeveless shirts. They encouraged people to wear shorts. So they were indeed wearing clothing. They were not naked. And they were wearing clothing that was culturally and situationally appropriate, at least for the part of the world where this study was done. And they had people do that two or three times a week. So in terms of a protocol that you might export from this study, basically getting outside for about 30 minutes, two or three times a week in a minimum of clothing, and yet still wearing enough clothing that is culturally appropriate. They were outside, they weren't sun bathing, flipping over on their back and front. They were just moving about doing things. They could read, they could talk, they could go about other activities, but they weren't wearing a broad brim hat or a hat of any kind, just getting a lot of sun exposure to their skin. They did this for a total of 10 to 12 UVB treatments. So this took several weeks, right? It took about a month, if you think about it, two or three times per week for a total of 10 to 12 UVB treatments. These treatments, of course, are just being outside in the sun. And then they measured hormones, and they measured the psychology of these male and female adult subjects. Let's first look at the psychological changes that these human subjects experienced after getting 10 to 12 of these UVB light exposure outdoor and sunlight type treatments. They

did this by collecting blood samples throughout the study, and they saw significant increases in the hormones, beta-estradiol, which is one of the major forms of estrogen, progesterone, another important steroid hormone, and testosterone in both men and women. Now, an important point is that the testosterone increases were significantly higher in men that happened to originate from countries that had low UV exposure compared to individuals from countries with high UV exposure. Now, this ought to make sense if we understand a little bit about how the skin functions as an endocrine organ. Many of you have probably heard of vitamin D3, which is a vitamin that we all make. Many people supplement it as well if they need additional vitamin D3. We all require sunlight in order to allow vitamin D3 to be synthesized and perform its roles in the body. And it turns out that people who have darker skin actually need more vitamin D3 and/or more sunlight exposure in order to activate that D3 pathway, than do people with paler skin. And this should make sense to all of you given what you now understand about melanocytes, that cell type that we discussed earlier, because melanocytes have pigment within them. And if you have darker skin, it means that you have more melanocytes or that you have melanocytes that are more efficient at creating pigment. And as a consequence, the light that lands on your skin will be absorbed by those melanocytes, and less of it is able to impact the D3 pathway. Whereas if you have pale skin, more of the light that lands on your skin can trigger the synthesis and assist the actions of vitamin D3. Similarly, in this study, they found that people who had paler skin and/or who originated from countries where they had less UVB light exposure across the year had greater, meaning more significant, increases in testosterone overall than did people who already were getting a lot of UVB exposure. This led them to explore so-called seasonal changes in testosterone that occurred normally in the absence of any light exposure treatment. So up until now, I've been talking about the aspects of this study involving people getting outside for about 20 to 30 minutes per day in sunlight, in a minimum of clothing. There was an increase in testosterone observed in both men and women.

00:58:09 Seasonality, Romantic Passion & Testosterone

The increases in testosterone were greater for people that had paler skin than darker skin. So the data I'm about to describe also come from this same paper, but do not involve 20 to 30 minute daily sun exposure protocols. It's simply addressing whether or



not testosterone levels change as a function of time of year. They measure testosterone across the 12-month calendar. This study was done on subjects living in the Northern Hemisphere for the entire year. And so in the months of January, February, and March, of course, the length of days is shortest and the length of nights is longest. And, of course, in the spring and summer months, June, July, August, September, and so on, the days are much longer and the nights are shorter. And what they observed was very obvious. They observed that testosterone levels were lowest in the winter months and were highest in the months of June, July, August, and September. Now, these are very important data. At least to my knowledge, these are the first data systematically exploring the levels of sex steroid hormones in humans as a function of time of year and thereby as a function of how much sunlight exposure they're getting. And what's remarkable about these data is that they map very well to the data in mice and the other data in this paper on humans, which illustrate that if you're getting more UVB exposure, your testosterone levels are higher. This study went a step further and explored whether or not the amount of sunlight exposure that one is getting to their skin influences their psychology in terms of whether or not they have increased desire to mate and so on. It's well known that sunlight exposure to the eyes can increase mood. And I talked about this in the podcast episode with my guest, Dr. Samer Hattar, who's the director of the chronobiology unit at the National Institutes of Mental Health. And Samer's recommendation is that people get as much bright light exposure as they safely can in the morning and throughout the day for sake of both sleep and energy, but also for enhancing mood and regulating appetite. In this study, it was found that both males and females had higher levels of romantic passion after getting the UV treatment. In fact, some of them reported increases in romantic passion from just one or two of these UV treatments. So they didn't have to go through all 10 or 12 in order to get a statistically significant increase in passion. Now, when we talk about passion, as the authors of this paper acknowledge, there's really two forms. There is emotional and sexual, and they parse this pretty finely. I don't want to go into all the details, and we can provide a reference and link to this study if you'd like to look at those details. But what they found was that women receiving this UVB light exposure focused more on increases in physical arousal and sexual passion, whereas the men actually scored higher on the cognitive dimensions of passion, such as obsessive thoughts about their partner and so on. Regardless, both males and females experienced and reported a increase in sexual passion and desire to mate. And we now know there were increases in testosterone and

estrogen, which of course could be driving the psychological changes, although I'm sure that those interact in both directions, meaning the hormones no doubt affect psychology and no doubt the psychology, these changes in passionate feelings, no doubt also increased or changed the hormone levels as well. And I want to reemphasize that there was a component of the study that had no deliberate daylight, sunlight exposure for 20 or 30 minutes, but rather just looked at hormone levels throughout the year and found that the increase in day length correlated with increases in testosterone and sexual passion. Now, in my opinion, this is a very noteworthy study because it really illustrates that sunlight and day length can impact the melatonin pathway and thereby take the foot off the brake, so to speak, on testosterone, estrogen, and the desire to mate. It also emphasizes that sunlight, UVB light,

#### 01:02:13 Tool: Skin Sun Exposure & Testosterone

can directly trigger hormone pathways and desire to mate and mating behavior. Now, this study went a step further in defining the precise mechanism by which light can impact all these hormones and this desire to mate. And here, understanding the mechanism is key if you want to export a particular protocol or tool that you might apply. We talked earlier about how UVB light exposure to the eyes triggers activation of these particular neurons within the eye, and then with centers deeper in the brain, and eventually the pineal gland to suppress the output of melatonin and thereby to allow testosterone and estrogen to exist at higher levels because melatonin can inhibit testosterone and estrogen. In this study, they were able to very clearly establish that it is sunlight exposure to our skin that is causing these hormone increases that they observed in mice and humans. And the way they did that was to use the so-called knockout technology, the ability to remove specific genes within specific tissues of the body. And what they found is that UVB light, meaning sunlight-exposed skin, upregulated, meaning increased the activity of something called p53, which is involved in the maturation of cells and various aspects of cellular function. And the cells they were focused on were the keratinocytes, which you are now familiar with from our earlier discussion about the fact that the epidermis of your skin contains mainly keratinocytes and melanocytes. Sunlight exposure increased p53 activity in the skin. And p53 activity was required for the downstream increases in ovarian size, in testicular size, in testosterone increases, in the estrogen increases, and the various other changes that

they observed at the physiological level when animals or humans were exposed to sunlight. So these data are important because what they mean is that not only is it important that we get sunlight exposure early in the day and throughout the day to our eyes, at least as much as is safely possible, but that we also need to get UVB sunlight exposure onto our skin if we want to activate this p53 pathway in keratinocytes and the testosterone and estrogen increases that are downstream of that p53 pathway. So even though the gene knockout studies were done on mice, they clearly show that if you remove p53 from the skin, that these effects simply do not occur. So in terms of thinking about a protocol to increase testosterone and estrogen, mood and feelings of passion, the idea is that you would want to get these two to three exposures per week, minimum of 20 to 30 minutes of sunlight exposure onto as much of your body as you can reasonably expose it to. And when I say reasonably, I mean, of course you have to obey cultural constraints, decency constraints. And of course you have to also obey the fact that sunlight can burn your skin. So many people are probably going to ask, "What happens if you wear sunscreen?" Well, in theory, because sunscreen has UV protection, it would block some of these effects. Now I'm not suggesting that people do away with sunscreen entirely. I do hope to do an episode all about sunscreen in the future because sunscreen is a bit of a controversial topic. Skin cancers are a real thing, and many people are especially prone to skin cancer, so you need to take that seriously. Some people are not very prone to skin cancers and can tolerate much more sun exposure. You're probably familiar with the simple fact that if you've gone outside on the beach with friends, some people get burned very easily, others don't. So you really should prioritize the health and the avoidance of sunburn on your skin. However, these data and other data point to the fact that we should all probably be striving to get more sunlight exposure onto our skin during the winter months and still getting sunlight exposure onto our skin

#### 01:06:13 Light & Improved Pain Tolerance

in the summer months, provided we can do that without damaging our skin. Another set of very impressive effects of UVB light, whether or not it comes from sunlight or from an artificial source, is the effect of UVB light on our tolerance for pain. It turns out that our tolerance for pain varies across the year and that our pain tolerance is increased in longer day conditions. And as we saw with the effects of UVB on hormones and mating,

again, this is occurring via UVB exposure to the skin and UVB exposure to the eyes. I want to just describe two studies that really capture the essence of these results. I'm going to discuss these in kind of a top contour fashion. I won't go into it as quite as much depth as I did the last study, but I will provide links to these studies as well. The first study is entitled Skin Exposure to Ultraviolet B Rapidly Activates Systemic, Neuroendocrine, and Immunosuppressive Responses. And you might hear that and think, "Oh, immunosuppressive that's bad." But basically what they observed is that even one exposure to UVB light changed the output of particular hormones and neurochemicals in the body, such as corticotropin hormone and beta-endorphins, which are these endogenous opioids. We've all heard of the opioid crisis, which is people getting addicted to opioids that they are taking in drug form, pharmaceuticals. But here I'm referring to endorphins that our body naturally manufactures and releases in order to counter pain and act as somewhat of a psychological soother also, because, of course, physical pain and emotional pain are intimately linked in the brain and body. What they found was that exposure to UVB light increased the release of these beta-endorphins. It caused essentially the release of an endogenous pain killer. Now, a second study that came out very recently, just this last week, in fact, published in the journal Neuron, Cell Press journal, excellent journal, is entitled A Visual Circuit Related to the Periaqueductal Gray Area for the Antinociceptive Effects of Bright Light Treatment. I'll translate a little bit of that for you. The periaqueductal gray is a region of the mid-brain that contains a lot of neurons that can release endogenous opioids, things like beta-enkephalin, things like enkephalin, things like mu opioid. These are all names of chemicals that your body can manufacture that act as endogenous pain killers and increase your tolerance for pain. They actually make you feel less pain overall by shutting down some of the neurons that perceive pain or by reducing their activity. Not to a dangerous level, right? They're not going to block the pain response so that you burn yourself unnecessarily or harm yourself unnecessarily, but they act a bit of a pain killer from the inside. If you heard the word antinociceptive, nociception is basically the perception or the way in which neurons respond to painful stimuli. So you can think of nociceptive events in your nervous system as painful events. And there I'm using a broad brush. I realized that the experts in pain will say, "Oh, it's not really a pain circuit," et cetera, et cetera. But for sake of today's discussion, it's fair to say that nociception is the perception of pain. So if this title is A Visual Circuit Related to the Periaqueductal Gray, which is this area that releases these endogenous opioids for the antinociceptive, the anti-pain effects of bright light treatment,

the key finding of this study is that it is light landing on the eyes and captured by the specific cells I was talking about earlier, those intrinsically photosensitive melanopsin ganglion cells is the long name for them, but these particular neurons in your eye, and in my eye incidentally, that communicate with particular brain areas. These brain areas have names. If you want to know them, for you aficionados or for you ultra curious folks, they have names like the ventral lateral geniculate nucleus and the intergeniculate leaflet. The names don't matter. The point is that light landing on the eyes is captured by these melanopsin cells. They absorb that light, translate that light into electrical signals that are handed off to areas of the brain, such as the ventral geniculate. And then the ventral geniculate communicates with this periaqueductal gray area to evoke the release of these endogenous opioids that soothe you and lead to less perception of pain. This is a really important study because it's long been known that in longer days or in bright light environments, we tolerate emotional and physical pain better. Previous studies had shown that it is light landing on our skin that mediates that effect, but only in part. It couldn't explain the entire effect. This very recent study indicates that it's also light arriving at the eyes, and in this case, again, UVB light, ultraviolet blue light of the sort that comes from sunlight, that is triggering these anti-pain or pain-relieving pathways. So once again, we have two parallel pathways. This is a theme you're going to hear over and over and over again, not just in this episode, but in all episodes of the Huberman Lab Podcast, because this is the way that your brain and body are built. Nature rarely relies on one mechanism in order to create an important phenomenon, and pain relief is an important phenomenon. So we now have at least two examples of the potent effects of UVB light exposure to the skin and to the eyes. One involving activation of testosterone and estrogen pathways, as it relates to mating, and another that relates to reducing the total amount

01:11:55 Protocol: Sun Exposure & Chronic Pain

of pain that we experience in response to any painful stimuli. So for those of you that are thinking tools and protocols, if you're somebody who's experiencing chronic pain, provided you can do it safely, try to get some UVB exposure, ideally from sunlight. I think the 20 to 30-minute protocol, two or three times per week is an excellent one, seems like a fairly low dose of UVB light exposure. It's hard to imagine getting much damage to the skin. Of course, if you have very sensitive skin, or if you live in an area of the world that

is very, very bright and has intense sunlight at particular times of year, you'll want to be cautious. Heed the warnings and considerations about sunscreen that I talked about earlier, or about wearing a hat. But the point is very clear. Most of us should be getting more UVB exposure from sunlight. I can already hear the screams within the comments or rather the questions within the comments, saying,

01:12:48 Tools: Sunlight (UVB), Blue-Light Blockers, Seasonal Affective Disorder (SAD)

"Well, what if I live in a part of the world where I don't get much UVB exposure?" And I want to emphasize something that I've also emphasized in the many discussions on this podcast related to sleep and circadian rhythms and alertness, which is even on a cloud-covered day, you are going to get far more light energy, photons through cloud cover than you are going to get from an indoor light source, an artificial light source. I can't emphasize this enough. If you look outside in the morning and you see some sunlight, if you see some sunlight throughout the day, you would do yourself a great favor to try and chase some of that sunlight and get into that sunlight to expose your eyes and your skin to that sunlight as much as you safely can. And when I say as much as you safely can, never ever look at any light, artificial, sunlight, or otherwise, that's so bright that it's painful to look at. It's fine to get that light arriving on your eyes indirectly. It's fine to wear eyeglasses or contact lenses. In fact, if you think about the biology of the eye and the way that those lenses work, that you will just serve to focus that light onto the very cells that you want those light beams to be delivered to, whereas sunglasses that are highly reflective or trying to get your sunlight exposure through a windshield of a car or through a window simply won't work. I'm sorry to tell you, but most windows are designed to filter out the UVB light. And if you're somebody who's really keen on blue blockers and you're wearing your blue blockers all day, well, don't wear them outside. And in fact, you're probably doing yourself a disservice by wearing them in the morning and in the daytime. There certainly is a place for blue blockers in the evening and nighttime, if you're having issues with falling and staying asleep. But if you think about it, blue blockers, what they're really doing is blocking those short wavelength, UVB wavelengths of light that you so desperately need to arrive at your retina and of course, also onto your skin in order to get these powerful biological effects on hormones and on pain reduction. And in terms of skin exposure, these data also might make you think a little bit about whether or not you should wear short sleeves or long sleeves, whether or not you want to wear

shorts or a skirt or pants. It's all going to depend on the context of your life and the social and other variables that are important, of course. I don't know each and every one of your circumstances, so I can't tell you to do X or Y or Z, nor would I, but you might take into consideration that it is the total amount of skin exposure that is going to allow you to capture more or fewer photons, depending on, for instance, if you're completely cloaked in clothing and you're just exposed in the hands, neck, and face such as I am now, or whether or not you're outside in shorts and a T-shirt, you're going to get very, very different patterns of biological signaling activation in those two circumstances. Many of you I'm guessing are wondering whether or not you should seek out UVB exposure throughout the entire year or only in the summer months. And that's sort of going to depend on whether or not you experience depression in the winter months, so called seasonal affective disorder. Some people have mild, some people have severe forms of seasonal affective disorder. Some people love the fall and winter and the shorter days. They love bundling up. They love the leaves. They love the snow, they love the cold, and they don't experience those psychological lows. So it varies tremendously. And there are genetic differences and birthplace origin differences that relate to all this, but really it has to be considered on a case-by-case basis. I personally believe, and this was reinforced by the director of the chronobiology unit at the National Institutes of Mental Health, Samer Hattar, that we would all do well to get more UVB exposure from sunlight throughout the entire year, provided we aren't burning our skin or damaging our eyes in some way. In addition to that, during the winter months, if you do experience some drop in energy or increase in depression or psychological lows, it can be very beneficial to access a SAD lamp. Or if you don't want to buy a SAD lamp, 'cause oftentimes they can be very expensive, you might do well to simply get a LED lighting panel. I've described one before. And I want to emphasize that I have no affiliation whatsoever to these commercial sources, but I've described one before and I'll describe it again. And we can provide a link to a couple examples of these in the show, in the show note captions, excuse me. This is a 930 to 1,000 lux, L-U-X, light source that's designed for drawing. It's literally a drawing box. It's a thin panel. It's about the size of a laptop. Very inexpensive compared to the typical SAD lamp. I actually have one, and I position it on my desk all day long. I also happen to have skylights above my desk. I'm fairly sensitive to the effects of light. So in longer days I feel much better than I do in shorter days. I've never suffered from full-blown seasonal affective disorder, but I keep that light source on throughout the day throughout the year. But I also make it a point to get outside and get

sunlight early in the morning and several times throughout the day. And if it's particularly overcast outside or there just doesn't seem to be a lot of sunlight coming through those clouds, I will try to look at that light source a little bit more each day in order to trigger these mechanisms. Now, some people may desire to get UVB exposure to their skin and they want to do that through sources other than sunlight. And there it's a little bit more complicated. There are, of course, tanning salons, which basically are beds of UVB light. That's really all they are. I've never been to one. I know people do frequent them in certain parts of the world. There, of course, people are covering their eyes. They are only getting UVB exposure to their skin, typically because the UVB exposure, or intensities rather, tend to be very, very high. And so you can actually damage your eyes. If you're looking at a very, very bright artificial UVB source up close. So you really have to explore these options for yourself. Sunlight of course, being the original and still the best way to get UVB exposure. So without knowing your particular circumstances, finances, genetics, or place of origin, et cetera, I can't know whether or not you need to use artificial sources. You're going to have to gauge that. Meanwhile, getting outside, looking at and getting some exposure of UVB onto your skin is going to be beneficial for the vast majority of people out there. And in fact, it's even going to be beneficial for people that are blind. People that are blind, provided they still have eyes, often maintain these melanopsin cells. So even if you're low vision or no vision, getting UVB exposure to your eyes can be very beneficial for sake of mood, hormone pathways, pain reduction, and so forth. A cautionary note, people who have retinitis pigmentosa, macular degeneration, or glaucoma, as well as people who are especially prone to skin cancers should definitely consult with your ophthalmologist and dermatologist before you start increasing

#### 01:19:44 Light & Enhanced Immune Function

the total amount of UVB exposure that you're getting from any source, sunlight or otherwise. There are additional, very interesting and powerful effects of UVB light, in particular on immune function. All the organs of our body are inside our skin. And so information about external conditions, meaning the environment that we're in, need to be communicated to the various organs of our body. Some of them have more direct access to what's going on outside. So for instance, the cells in your brain that reside right over the roof of your mouth, your hypothalamus, they control hormone output, and



they control the biological functions that we call circadian functions, the ones that change every 24 hours. Well, those are just one or two connections, meaning synapses away from those cells in your eye that perceive UV, UVB light, excuse me. Other organs of your body, such as your spleen, which is involved in the creation of molecules and cells that combat infection, well, those are a long ways away from those cell in your eye. And in fact, they're a long ways away from your skin. There are beautiful studies showing that if we get more UVB exposure from sunlight or from appropriate artificial sources, that spleen and immune function are enhanced, and there's a very logical, well-established circuit as to how that happens. Your brain actually connects to your spleen. Now, it's not the case that you can simply think, "Okay, spleen, turn on, release killer cells, go out and combat infection." However, UVB light arriving on the eyes is known to trigger activation of the neurons within the so-called sympathetic nervous system. These neurons are part of the larger thing that we call the autonomic nervous system, meaning it's below or not accessible by conscious control. It's the thing that controls your heartbeat, controls your breathing and that also activates or flips on the switch of your immune system. When we get a lot of UVB light in our eyes, or I should say sufficient UVB light in our eyes, a particular channel, a particular set of connections within the sympathetic nervous system is activated, and our spleen deploys immune cells and molecules that scavenge for and combat infection. So if you've noticed that you get fewer colds and flus and other forms of illness in the summer months, part of that could be because of the increase in temperature in your environment, because typically longer days are associated with more warmth in your environment as opposed to winter days, which are short when it tends to be colder out. Well, that's true, but it's also the case that people around you have fewer colds and flus and that you will get infected with fewer colds and flus and other infections, because if those infections, whether or not they're bacterial or viral, arrive in your body, right, if you inhale them or they get into your mouth or on your skin, your spleen meets those infections with a greater output. In other words, the soldiers of your immune system, the chemicals and cell types of your immune system that combat infection are in a more ready, deployed stance, if you will. If you want to know more about the immune system and immune function, I did an entire episode about the immune system and the brain, you can find that at [hubermanlab.com](http://hubermanlab.com). We talk about cytokines, we talk about killer cells, B cells, T cells, et cetera, a lot of detail there. So we often think about the summer months and the spring months as fewer infections floating around. But in fact, there aren't fewer infections floating around. We

are simply better at combating those infections, and therefore there's less infection floating around.

#### 01:23:30 Tool: Light During Winter Months

So we are still confronted with a lot of infections. We're just able to combat them better. What does this mean in terms of a tool? What it means is that during the winter months, we should be especially conscious of accessing UVB light to enhance our spleen function, to make sure that our sympathetic nervous system is activated to a sufficient level to keep our immune system deploying all those killer T cells and B cells and cytokines so that when we encounter the infections, as we inevitably will, right, we're constantly being bombarded with potential infections, that we can combat those infections well. And as just a brief aside, but I should mention, a brief aside that's related to tens of thousands of quality studies, it is well known that wound healing is faster when we are getting sufficient UVB exposure. Typically, that's associated with the longer days of spring and summer. It is known that turnover of hair cells, the very cells that give rise to hair cells are called stem cells. They live in little so-called niches in our skin with these hair stem cells, and your hair grows faster in longer days. That too is triggered by UVB exposure, not just to the skin, but to the eyes. That's right. There was a study published in the Proceedings of the National Academy of Sciences a couple of years ago that showed that the exposure of those melanopsin ganglion cells in your eyes is absolutely critical for triggering the turnover of stem cells in both the skin and hair, and also turns out in nails. So if you've noticed that your skin, your hair and your nails look better and turn over more, meaning grow faster in longer days, that is not on a coincidence. That is not just your perception. In fact, hair grows more, skin turns over more, meaning it's going to look more youthful. You're going to essentially remove older skin cells and replace them with new cells, and all the renewing cells and tissues of our body are going to proliferate, are going to recreate themselves more when we're getting sufficient UVB light to our eyes and also to our skin. And so while some of you may think of light therapies such as red light therapies or UVB therapies as kind of new agey, or just biohacking, again, a phrase I don't particularly like, this notion of biohacking, 'cause it implies using one thing for a purpose that it was never tended to have, well, it turns out that UVB exposure and red light, as we'll soon see, is a very potent form of increasing things like wound healing and skin health for very logical mechanistically backed

reasons. So while I can't account for everything that's being promoted out there in terms of this light source will help your skin look more youthful

#### 01:26:18 Light Therapies: Local vs. Systemic Exposure

or will help heal your scars, the mechanistic basis for light having those effects makes total sense. But what you should consider, however, is that if the particular light therapy that you're considering involves very local application rather than illuminating broad swaths of skin, and if it has no involvement with the eyes, meaning there's no delivery of UVB or red light or the other light therapy to the eyes, it's probably not going to be as potent a treatment as would a more systemic activation of larger areas of skin and the eyes. Now, again, a cautionary note, I don't want people taking technologies that were designed for local application and beaming those into the eyes. That could be very, very bad and damaging to your retinal and other tissues. Certainly, wouldn't want you taking bright light of very high intensity of any kind and getting cavalier about that. Typically, the local illumination of say a wound or a particular patch of acne or some other form of skin treatment involves very high intensity light. And if the intensity is too high, you can actually damage that skin. And so as we'll talk about in a few moments, most of those therapies for modifying skin involve actually burning off a small, very thin layer at the top of the epidermis in efforts to trigger the renewal or the activation of stem cells that will replenish that with new cells. So there's a fine line to be had between light therapies that are very localized and intense, which are designed to damage skin and cause reactivation of new stem cells, whether that's hair cells or skin cells, et cetera, versus systemic activation across broad swaths of skin and the eyes. You really have to consider this on a case-by-case basis, but at least for now just consider that increases in hormones, reduction in pain by way of increases in enkephalin and other endogenous opioids, improving immune status by activating the spleen, and so on, and so on really are all the downstream consequence of illuminating large swaths of skin and making sure that those neurons within the eye get their adequate UVB exposure or other light wavelength exposure, not simply beaming a particular wavelength of light at a particular location on the body and hoping that that particular illumination at a particular location on the body is going to somehow change the biology at that location. Our biology just really doesn't work that way. It's possible, but in general, systemic effects through broad scale illumination and illumination to the eye,

## 01:28:54 Tool: Improving Mood, Timing of Natural & Artificial Light

combined with local treatments are very likely to be the ones that have the most success. Now, I'd like to shift our attention to the effects of light on mood more specifically. We talked about this in terms of seasonal affective disorder, but many of us don't suffer from seasonal affective disorder. So I'd like to drill a little deeper into how light impacts mood. And here, I want to, again, paraphrase the statements of Dr. Samer Hattar at the National Institutes of Mental Health, I should mention the director of the chronobiology unit at the National Institutes of Mental Health and perhaps one of the top one to two to three world experts in how light can impact mood, appetite, circadian rhythms, and so forth. Samer stated on the podcast, and he said in various other venues as well, that getting as much UVB light in our eyes and on our skin in the early day and throughout the day as is safely possible is going to be beneficial for mood. There's also another time of day, or rather I should say a time of night in which UVB can be leveraged in order to improve mood, but it's actually the inverse of everything we've been talking about up until now. We have a particular neural circuit that originates with those melanopsin cells in our eye that bypass all the areas of the brain associated with circadian clocks, so everything related to sleep and wakefulness, that's specifically dedicated to the pathways involving the release of molecules like dopamine, the neuromodulator that's associated with motivation, with feeling good, with feeling like there's possibility in the world, and so on and so forth, and other molecules as well, including serotonin and some of those endogenous opioids that we talked about before. That particular pathway involves a brain structure called the perihabenular nucleus. The perihabenular nucleus gets input from the cells in the eye that respond to UVB light, and frankly, to bright light of other wavelengths as well, 'cause as you recall, if a light is bright enough, even if it's not UV or blue light, it can activate those cells in the eye. Those cells in the eye communicate to the perihabenular nucleus. And as it turns out, if this pathway is activated at the wrong time of each 24-hour cycle, mood gets worse, dopamine output gets worse, molecules that are there specifically to make us feel good, actually are reduced in their output. So while UVB exposure in the morning and throughout the day is going to be very important for elevating and maintaining elevated mood, avoiding UVB light at night is actually a way in which we can prevent activation of this eye to perihabenular pathway that can actually turn on depression. To be very direct and

succinct about this, avoid exposure to UVB light from artificial sources between the hours of 10:00 pm and 4:00 am. And if you're somebody who suffers from low mood and overall has a kind of mild depression or even severe depression, of course, please see a psychiatrist, see a trained psychologist, get that treated, but you would do especially well to avoid UVB exposure from artificial sources, not just from 10:00 pm to 4:00 am, but really be careful about getting too much exposure to UVB even in the late evening, so 8:00 pm perhaps to 4:00 am. I can't emphasize this enough, that if you view UVB light, you activate those neurons in your eye very potently. And if those cells communicate to the perihabenular nucleus, which they do, you will truncate or reduce the amount of dopamine that you release. So if you want to keep your mood elevated, get a lot of light, UVB light, throughout the day,

#### 01:32:44 Light Conditions & Sleep Optimization

and at night, really be cautious about getting UVB exposure from artificial sources. Now let's say you're somebody who has no issues with mood. You're just the happiest person all year long, or maybe you just have subtle variations in your mood. You feel great about that. Turns out that you still want to be very careful about light exposure between the hours of 10:00 pm or so, and 4:00 am, in fact, even during sleep. There's a recent study that just came out in the Proceedings of the National Academy of Sciences, and it's entitled Light Exposure During Sleep Impairs Cardiometabolic Function. This is a very interesting study where they took human subjects, young adults, and having them sleep in rooms that had different lighting conditions, either dim light or slightly bright light. Now, many people can't fall asleep in brightly lit rooms, so they acknowledge this. These were not very brightly lit rooms. These were rooms that had just a little bit of overhead room lighting, a hundred lux, which is not very bright at all. Or they had them sleep in a room that had very dim light, which is less than three lux. If you want to get a sense of how bright three lux is versus a hundred lux, I would encourage you to download the free app Light Meter. I have no relationship to the app. It's a pretty cool app, however. I've used it for a long time, where you can basically point your phone at a particular light source, sun or otherwise, and you just press the button and it'll give you an approximate readout of lux, which is the light intensity that the phone happens to be staring out at at that location. It's not exact, but it's a pretty good back-of-the-envelope measure of light intensity. So these subjects were either sleeping in a very dim room, three lux is very,

very dim, or a somewhat dim room, a hundred lux. In this study, they measured things like melatonin levels. They looked at heart rate, they looked at measures of insulin and glucose management. Now, in previous episodes, I've talked about how glucose, blood sugar, is regulated by insulin because you don't want your glucose levels to be too high, hyperglycemia, or too low, hypoglycemia. And the hormone insulin is involved in sequestering and shuttling glucose in the bloodstream. Basically, how well you manage glucose in the bloodstream can be indirectly measured by your insulin levels. And it's well known that sleep deprivation can disrupt glucose regulation by insulin. However, in this study, subjects were sleeping the whole night through. It just so happens that some of the subjects were sleeping in this very dimly lit room, three lux, and other subjects were sleeping in a somewhat dimly lit room, a hundred lux. What's incredible about this study is that both rooms were sufficiently dimmed that melatonin levels were not altered in either case. This is really key. It's not as if one group experienced a lot of bright light through their eyelids and others did not. Melatonin levels were not disrupted. And given how potently light can inhibit melatonin, this speaks to the fact that this very dim condition of three lux and the somewhat dim condition of a hundred lux was not actually perceived by the subjects nor was it disrupting these hormone pathways. They also looked at glucose responses. They had people essentially take a fasting glucose test in different conditions. I won't go into all the details, but here's what they found. In healthy adults, even just one night of sleeping in a moderately lit environment, this hundred lux environment, caused changes, increases in nighttime heart rate, which means that the sympathetic nervous system was overly active as compared to people that slept in a completely dark or in a very, very dimly lit room. Decreases in heart rate variability, and here I should point out that heart rate variability or HRV is a good thing, we want heart rate variability. So they saw increases in heart rate, decreases in heart rate variability, and increases in next morning insulin resistance, which is an indication that glucose management is suffering. So this is powerful. The results of this study essentially indicate that even just one night of sleeping the whole night through in a dimly lit environment is disrupting the way that our autonomic nervous system is functioning, altering so called autonomic tone, making us less relaxed is probably the best way to describe it, even though we are asleep, disrupting the way that our cardiometabolic function operates, such that we have lower heart rate variability and increased insulin resistance. This is not a good thing for any of us to experience. So while we've mainly been talking about the positive effects of UVB light and other forms of light, now we have

two examples. One from the work of Hattar and colleagues showing that UVB exposure via the perihabenua can diminish the output of dopamine and other molecules that make us feel good if that UVB exposure is in the middle of the night or late evening. And now we have yet another study performed, in this case, in humans, indicating that even if we fall asleep and sleep the whole night through, if the room that we're sleeping in has too many lux, too much light energy, that light energy is no doubt going through the eyelids, which it can, activating the particular cells in the eye that trigger an increase in sympathetic nervous system activation and disrupting our metabolism. And this study rests on a number of other recent studies published in Cell, which is a superb journal, and other journals, showing that during the course of a healthy, deep night's sleep, our body actually transitions through various forms of metabolic function. We actually experience ketosis-like states. We experience gluconeogenesis. We experience different forms of metabolism associated with different stages of sleep, not something that we're going into in depth in this podcast, we will in a future podcast. What this study shows is that light exposure even in sleep is disrupting our autonomic, in this case, the sympathetic arm of the autonomic nervous system in ways that are disrupting metabolism, probably in sleep, but certainly outside of sleep so that we wake up and have our first meal of the day. Or even if you're intermittent fasting, you eat that first meal of the day, if your sleep is taking place in an environment

#### 01:39:00 Infrared Light, Skin & Wound Healing

that's overly illuminated, well, that's disrupting your cardiac function and your metabolism. I've been talking a lot about UVB light, which is short wavelength light. So UV light, blue light, maybe even some blue green light, that's going to be short wavelength light. Now, I'd like to shift our attention to the other end of the spectrum, meaning the light spectrum, to talk about red light and infrared light, which is long wavelength light. Many so-called low level light therapies, the acronym is LLLT, low level light therapies, involve the use of red light and infrared light. Sometimes, low level light therapies involve the use of UVB, but more often than not these days, when we hear LLLT, low level light therapy, it's referring to red light and near-infrared light therapies. Low level light therapies have been shown to be effective for a huge number of biological phenomenon and medical treatments. I can't summarize all of those now. It would take me many, many hours. It would be an effective episode for curing insomnia,

but it wouldn't inform you properly about the use of light for your health. Rather, I'd like to just emphasize some of the top contour of those studies and point out that for instance, low level light therapy with infrared light has been shown to be effective for the treatment of acne and other sorts of skin lesions. There have been some really nice studies actually where they use subjects as their own internal control. So people, believe it or not, agreed to have half of their face illuminated with red light or near-infrared light, and the other half of their face serve as a control, and to do that for several weeks at a time. And you can see pretty impressive reductions in skin lesions, reductions in scars from acne, and reduction in acne lesions themselves, meaning the accumulation of new acne cysts with low level light therapy, using red light and infrared light. Sometimes however, there is a resistance of that acne to the low level light therapy, such that people will get an initial improvement, and then it'll go away despite continuing the treatment. So you're probably asking, or at least you should be asking, how is it that shining red light on our skin can impact things like acne and wound healing, et cetera? Well, to understand that, we have to think back to the beginning of the episode where I described how long wavelength light, such as red light and near-infrared light, which is even longer than red light, can pass through certain surfaces, including our skin. So our skin has an epidermis, which is on the outside, and the dermis, which is in the deeper layers. Red light and infrared light can pass down into the deeper layers of our skin, where it can change the metabolic function of particular cells. So let's just take acne as an example. Within the dermis, the deep layers of our skin, we have what are called sebaceous glands that actually make the oil that is present in our skin. Those sebaceous glands are often nearby hair follicles. So if you've ever had a infected hair follicle, that's not a coincidence that hair follicles tend to get infected. Part of it is because there's actually a portal down and around the hair follicle, but the sebaceous gland is where the oil is created. That is going to give rise to, for instance, acne lesions. Also, in the dermis, in the deep layers of the skin, are the melanocytes. They're not just in the epidermis, they're also in the deeper layers of the skin. And you have the stem cells that give rise to additional skin cells. If the top layers of the epidermis are damaged, those stem cells can become activated. And you also have the stem cells that give rise to hair follicles. So by shining red light or near-infrared light on a localized patch of skin, provided that red light is not of such high intensity that it burns the skin, but is of sufficient intensity that it provides just a little bit of damage to the upper layers of the skin, the epidermis, and that it triggers certain biological pathways within the cells of the sebaceous gland and the



stem cells within the hair cell niche and the stem cells in skin, what happens is the top layers of the skin are basically burned off by a very low level of burn and/or the cells in the deeper layer start to churn out new cells, which go and rescue the lesion, essentially clear out the lesion and replace that lesion with healthy skin cells. This does work in the context of wound healing, getting scars to disappear. It also works to remove certain patches of pigmentation. There are sometimes cases where people will get a red blotchiness due to certain skin conditions or some darker pigmentation that they want remove, or that they need removed, because it's a potential skin cancer threat. Now, how is red light actually doing it within the cells of the sebaceous gland, the stem cells, et cetera? Well, long wavelength light can actually get deep into the skin, I mentioned that before, but can also get into individual cells and can access the so-called organelles, which I described at the beginning of the episode. In particular, they can access the mitochondria, which are responsible for producing ATP. Now, the simple way to think about this for sake of this discussion is that as cells age, and in particular, in very metabolically active cells, they accumulate what are called ROSs, reactive oxygen species. And as reactive oxygen species go up, ATP energy production in those cells tends to go down. It's a general statement, but it's a general statement that in most cases is true. There are some minor exceptions that don't concern us that have to do with cell types different than the ones that I'm talking about now. So the way to think about this is that red light passes into the deeper layers of the skin, activates mitochondria, which increases ATP, and directly or indirectly reduces these reactive oxygen species. These reactive oxygen species are not good. We don't want them. They cause cellular damage, cellular death. And for the most part just inhibit the way that our cells work. So if you've heard of red light or near-infrared light therapies designed to heal skin or improve skin quality or remove lesions, or get rid of scars or unwanted pigmentation, that is not pseudoscience, that is not woo science. That is grounded in the very biology of how light interacts with mitochondria and reactive oxygen species. Some of you may also find it interesting to note that some of the cream-based treatments for acne, for instance, like retinoic acid, Retin-A, is actually a derivative of vitamin A. And the pathway involving retinoic acid and vitamin A, believe it or not, is very similar to the natural biological pathway by which photopigments in the eye convert light information into biological changes within those cells. So the key point here is that light is activating particular pathways in cells that can either drive death of cells or can make those cells essentially younger

## 01:46:00 Infrared Light Therapy & Skin, Low-Level Laser (Light) Therapy (LLLT)

by increasing ATP by way of improving mitochondrial function. And in recent years, there have been some just beautiful examples that exist, not only in the realm of skin biology, but in the realm of neurobiology whereby red light and near-infrared light can actually be used to enhance the function of the cells that, for instance, allow us to see better and indeed cells that allow us to think better. So now I'd like to review those data because not only are they interesting in their own right, but they also point to some very interesting and powerful application of low-cost or zero-cost tools that we can use to improve our vision. If you are somebody who's interested in the use of red light or near-infrared light, so-called LLLT, low level light therapies, for treatment of dermatologic issues, so anything related to skin, I will include a link to an excellent set of reviews. The first one is Light-emitting Diodes in Dermatology: A Systematic Review of Randomized Controlled Trials. That one includes review of a very large number of studies, came out just a few years ago in 2018, and I think is very clearly and cleanly laid out for anyone to access. And you can see the degree of effects of red light, for instance, on treatment of acne or scarring, et cetera. And I'll also provide a link to another review, which is Low-level Light Therapy in Skin: Stimulating, Healing, and Restoring. So for those of you that are interested, again, in dermatologic issues and the kind of restoring youthfulness and the kind of general themes of anti-aging and longevity and how red light therapies can be used for that, I would encourage you to take a look at those reviews. What you're going to find is that rarely, if ever, is there a study looking at whole body red light illumination for sake of treating and improving skin. And I mention this because I get a lot of questions about infrared sauna and global illumination with red lights. We'll talk more about cases where global illumination of your whole body or your whole face with red lights might be useful, but in terms of infrared sauna, I've mentioned on this podcast before, and I will certainly go deeper on this in an upcoming episode, all about the use of heat and temperature for augmenting our biology, but in general, infrared saunas don't get hot enough, temperature-wise, in order to trigger some of the important effects on growth hormone and heat shock proteins and some of the other things that sauna has been shown to be excellent for. That's a general statement. I realize there are some infrared saunas that do get hot enough. There are very few data on the use of whole body illumination with infrared saunas that really point to any specific mechanistically

supported effects. Almost all the positive effects that you're going to see of red light and low-level light therapies, certainly the ones discussed in the reviews that I just mentioned, are going to be the consequence of very directed illumination of particular patches of skin that are seeking repair, that people are seeking the repair of. So again, I don't want to disparage infrared saunas, but in general, they don't get hot enough to trigger most of the positive effects that saunas have been demonstrated to have. And it's unclear at all as to whether or not they can enhance skin quality, youthfulness, restore top layers of skin that are damaged, repair acne, et cetera.

#### 01:49:20 Infrared Light & Age-Related Vision Loss

So more on heat saunas and infrared saunas and their comparison in an upcoming episode. So let's talk about a clear set of examples where red light and near-infrared light have been shown to have positive effects on our health. And these are the data that I referred to at the beginning of the episode from Dr. Glen Jeffery at University College London, who, again, is a longstanding member of the neuroscience community, working on visual neuroscience, and who over the last decade or so has really emphasized the exploration of red light and near-infrared light for restoration of neuronal function as we age. This is absolutely critical. We know that we don't accumulate many new brain cells as we get older. And in some areas of our nervous system, such as our neural retina, which is the part of our eye, that's responsible for translating light information to electrical signals so that we can see, we don't get any new cells after the time in which we were born. So the ability to keep our neurons healthy is extremely important for our visual system, extremely important for our hippocampus, an area of the brain involved in memory. And I should just mention that even if people don't get Alzheimer's, there's always going to be some degree of age-related dementia. Sadly, nobody is as cognitively sharp in the years before they die, as they are 20 years before that. It's just never the case. We're all getting worse at thinking, feeling, perceiving, et cetera. The question is how quickly we are getting worse. So any mechanism by which we can preserve or reverse neuronal function turns out to be immensely beneficial. The Jeffery Lab has published two studies in recent years on humans that looked directly, no pun intended, at how red light and near-infrared light can improve visual function. I'm going to describe the parameters of those studies. And then I'm going to describe what they found, exactly. The mechanistic motivation for these studies, again, traces back to this

effect of light on mitochondria. So to go a little bit deeper into that mechanism just briefly so that you can frame any potential protocol that you would develop, when light arrives on cells, including neurons, that light can penetrate into the cells if it's of the appropriate wavelength. Red light can do that, it can get into cells, it can access the mitochondria, it can increase ATP. In general, anytime ATP is doing its thing to increase energy in cells, it's involving this thing called cytochrome c, which is an oxidase. Anytime you hear ase, A-S-E, in biology, it's going to be an enzyme. It's involved in some process of degrading a molecule and creating another molecule, typically. So ATP and cytochrome c is going to give you ATP. Now, that's a great thing, but it creates a byproduct. It breaks things down, such that you get these ROSs, these reactive oxygen species. And those reactive oxygen species, for those of you that want to know, are involved in things like redox signaling. And reactive oxygen species actually change which genes are made in a cell. So the goal of any treatment is to keep neurons or other cells youthful and functioning well, and to prevent or reverse aging, is going to be to increase ATP and to reduce reactive oxygen species, and in doing so, to disrupt some of the normal pathways associated with aging. The Jeffery Lab approached these studies with that understanding of how mitochondria and reactive oxygen species and ATP work. And what they did was exquisitely simple to the point of being elegant. And what they found was really, really exciting. What they did is they had people, subjects that were either younger, so in their 20s, or 40 years old or older, view red light of about 670 nanometers. 670 nanometers would appear red to you and me. They, they had them do that, excuse me, at a distance that was safe for their eyes, so at about a foot away. Now, a foot away from a very intense red light could actually be damaging to the eyes, so they had them do this at about a foot away from a red light that was of low enough intensity that it did not damage the eyes. And they had them do that anywhere from two to three minutes per day. And in one study, they had them do that for a long period of time of about 12 weeks. And in the other study, they had them do that just for a couple of weeks. What's remarkable is that when you collapse the results across these two studies, what they found is that when looking at these subjects ranging from 28 years old to about 72 years old, the major findings were that in individuals 40 years old or older, so in the 40 to 72-year-old bracket, but not in the subjects younger than 40 years old, they saw an improvement in visual function. That improvement in visual function was an improvement in visual acuity, meaning the ability to resolve fine detail, and using a particular measure of visual function, which is called the Tritan exam. T-R-I-T-A-N, Tritan

exam, which specifically addresses the function of the so-called short wavelength cones, the ones that respond to green and blue light, they saw a 22% improvement in visual acuity, which in the landscape of visual testing is an extremely exciting result. Okay, so I think in most studies of improvements of vision, you'd be very excited to see an improvement of 5% or 10%. So a 22% improvement in visual acuity, even though it's in this very specific form of visual testing, this Tritan exam or this Tritan score, well, that turns out to be very significant and translates to the real world in an important way. In particular, as we age, we tend to lose certain neurons within our retina, but we don't tend to lose cones. We tend to lose rods. We tend to lose other cells within the retina, including the cells that connect the eye to the brain, the so-called ganglion cells. Cones, for whatever reason, are pretty resilient to age-related loss. However, because rods and cones both are not just among the most metabolically active cells in your entire body, but the most metabolically active cells in your entire body that's right, your rods and cones are the cells that demand, and that use the most energy of all the cells in your body, not your skin cells, not your spleen, not your stomach cells. Even if you talk a lot, not the cells that are responsible for moving your mouth. It is the rods and cones of your neural retina that are responsible for using the most amount of ATP and energy in your entire body. And because of that, those cells tend to accumulate a lot of reactive oxygen species as we age. Red light of the sort used in these studies was able to reduce the amount of reactive oxygen species in the rods and cones and to rescue the function of this particular cone type, the short wavelength and medium wavelength cones, which if you think about the study, is a little bit surprising, because it was red light and near-infrared light, not short wavelength light, that was used in order to create this improvement in cellular function. But if you step back a little bit further, it makes perfect sense because there's nothing specific about the red light in the sense that it gets delivered only to red cones. That red light and near-infrared light is being absorbed by all the photoreceptors within the eye, the rods and the blue cones and the green cones and the red cones. It's just that the red cones absorb that light best. So the important takeaway here is that viewing red light and near-infrared light at a distance at which it is safe for just a couple of minutes each day allowed a reversal of the aging process of these neurons, which some people have heard me say before, and I'll just say it again, the retina, including your photoreceptors, are not just connected to your brain. They're not just near your brain. They are actual central nervous system tissue. They are the only two pieces of your brain, meaning your neuroretinas are the only two pieces of your

brain that reside outside your skull, or at least outside the cranial vault. So here we're seeing a reversal of the aging process in neurons by shining red light on those neurons. Now, of course, the Jeffery Lab is primarily interested in vision, and humans are most dependent on vision as a sense to navigate the world and survive. So this is really wonderful. Here, we're looking at a therapy that can reverse age-related vision loss, at least in some individuals. But as you can imagine, the study was also done on these cells because they reside outside the skull and you can shine light directly on them, right? I'm sure that there are many people out there who are interested in how they can improve the function, say, of the neurons in their brain responsible for memory. And in a few minutes, I'll describe the non-invasive applications of light to try and restore the function of those cells as well. So a little bit more about the studies from the Jeffery Lab. One of the things that they observed was a reduction in so-called drusen, D-R-U-S-E-N. Drusen are little fatty deposits, little cholesterol deposits, that accumulate in the eye as we age. We've all heard about cholesterol within our veins and arteries and how that can clog our veins and arteries and how, of course, clogging of veins and arteries is not a good thing. Well, our neural retina being so metabolically active requires a lot of blood flow. It's heavily vascularized, and drusen are a special form of cholesterol that accumulate in the eye. As it turns out, these red light and near-infrared light therapies explored by the Jeffery Lab were able to actually reduce or reverse some of the accumulation of drusen. And so in addition to reducing reactive oxygen species, the idea in mind now is that red light may actually reduce cholesterol deposits

01:59:36 Tools: Infrared Panels, Morning Exposure

and reactive oxygen species in order to improve neuronal function. So what should you and I do with these results? Or should we do anything with these results? Well, first of all, I want to emphasize that even though these studies are very exciting, they are fairly recent. And so more data, as always, are needed. There's some additional features of these studies that I think are also important to consider. First of all, the exposure to red light needed to happen early in the day, at least within the first three hours of waking. How would one do that? Well, nowadays there are a number of different red light panels and different red light sources that certainly fall within the range of red light and near-infrared light that one could use. I don't have any affiliation to any companies or products that promote or make those red light therapies. I do own a red light panel, so I confess I

have started using this protocol. I am older than 40 years old. I also have been experimenting with these red light panels as a way of addressing other changes in biological tissues, for which I'm doing blood work, et cetera. And I'm going to talk about that in a future episode, but that, of course, is what I call anecdotal. It only relates to my experience. So today, and certainly on all episodes of the Huberman Lab Podcast, we emphasize peer-reviewed studies almost exclusively, talking about anecdotal only when highlighting it as anecdotal. So if you're somebody who wants to explore red light therapy, here's what you need to do. You need to make sure that that red light source, whatever source you happen to use, whether or not you purchase it or make one... And in fact, these red light sources are very, very easy to make. You could essentially take a bright flashlight and cover it with a film or a filter that would only allow particular long wavelengths to pass through. This would be very easy to look up online and figure out how to do this. You could probably do this for, you know, just a few dollars or you could purchase a red light unit if that was within your budget and something that you're interested in. You want to make sure that it's not so bright that you're damaging your eye. A good rule of thumb is that something isn't painful to look at. And in fact, I should just emphasize that any time you look at any light source, sunlight or otherwise, that's painful and makes you want to squint or close your eyes, that means it's too bright to look at without closing your eyes. Okay, that's sort of a duh, but I would loathe to think that anyone would harm themselves with bright light in any way. I don't just say that to protect us. I say that to protect you, of course, because you are responsible for your health. And again, retinal neurons do not regenerate. Once they are gone and dead, they do not come back. There's no technology to replace them at this current state in time. So please don't damage your retinas. So is a red light source safe to look at if it is not painful to look at? Chances are it is. And yet I would still encourage you to talk to your optometrist or ophthalmologist before getting into any extensive protocols. But if you are still determined to pursue the sorts of protocols that are in the Jeffery studies, certainly we'll provide a link to those studies. Again, it involved looking at these red light panels, blinking aloud for two minutes to three minutes every morning for a period of two weeks or more. And if you're older than 40, that could very well have an effect. If you're longer, younger than 40, excuse me, that's unlikely to have an effect. At least that was what was observed in these particular studies. The lights were not flashing. It was continuous illumination. Again, you're allowed to blink. It does not have to even be direct illumination. It can be somewhat indirect illumination, much as we described for the use

of UVB light before. The wavelength of light is important. It is red light and near-infrared light that is going to be effective in this scenario. The authors of this study emphasized that it was red light of 670 nanometers in wavelength and near-infrared light of 790 nanometers in wavelength that were effective and that those wavelengths could be complimentary. That's probably why, or maybe it's just coincidental, but it's a fortunate coincidence that a lot of the commercially available red light panels that you'll find out there combine both red light and near-infrared light. However, I want to emphasize that most of the panels that are commercially available are going to be too bright to safely look at very close up. And in fact, that's why most of those red light panels are designed for illumination of the skin and oftentimes arrive in their packaging with eye protectors that are actually designed to shield out all the red light. So take the potential dangers of excessive illumination of the eyes with any wavelength of light seriously. But if you're going to explore 670 and 790 nanometer light for sake of enhancing neuronal function, set it at a distance that's comfortable to look at, and that doesn't force you to squint or doesn't make you feel uncomfortable physically, as if you need to turn away during the period of that two to three-minute illumination each day. In terms of turning away from light, I'll just briefly mention that that is not an accident or a coincidence that you have that response to very bright light. There is a so-called photic avoidance pathway that involves cells within your retina, these ganglion cells that communicate with yet another brain station, a certain area of your thalamus that communicate to areas of your brain that are associated with pain. So literally that can trigger headache, and that can trigger the squint reflex. Biology is just beautiful in this way. Too much light is bad for us in that it can damage our eyes and other aspects of our body. So if we look at a light that's too bright, our eyes send a signal to the brain that gives us a sort of a headache and a desire to squint and turn away. So that can be a useful guide in terms of gauging how bright a light should be

#### 02:05:22 Infrared Light at Night, Shift Work

or at least how far away you should be from a bright source in order to safely engage with that light source. So the studies I just described, once again, involve the use of red light early in the day within three hours of waking and are for the sake of improving neuronal function. Red light has also been shown to be beneficial late in the day and even in the middle of the night. And when I say middle of the night, I'm referring to



studies that explore the use of red light for shift workers. I know that most people are not working in the middle of the night, at least I hope they're not, but some of you may do that from time to time. All-nighters for studying, I confess I still pull all-nighters every once in a while to prepare things like podcasts and other deadlines. I really try not to, happens less and less as I get older, because I think I get more disciplined and/or less good at pulling all-nighters. But I realize that many people are doing shift work, or they have to work certainly past 10:00 pm. Or maybe they're taking care of young children in the middle of the night, and they have to be up. In that case, red light can actually be very beneficial. And nowadays there are a lot of sources of red light available just as red light bulbs. You don't need a panel. So what I'm basically saying is that it can be beneficial to use red lights at night. The study I'd like to emphasize in this context is entitled, Red Light: A Novel Non-pharmacological Intervention to Promote Alertness in Shift Workers. It's a beautiful study. They explored the use of different wavelengths of light, so blue light of 460 nanometers or red light or dim white light, of different brightnesses, et cetera, and looked at things like melatonin. How much does light of a given color and intensity suppress melatonin? They looked at cortisol, a stress hormone. They looked at wakefulness, how much or to what degree could a given color of light increase wakefulness at different hours of the day? The takeaway from this study is very clear. If you need to be awake late at night for sake of shift work or studying or taking care of children, et cetera, red light is going to be your best choice because if the red light is sufficiently dim, it's not going to inhibit melatonin production, and it's not going to increase cortisol at night. Cortisol should be high early in the day, or at least should be elevated relative to other times of day if you are healthy. A late shifted increase in cortisol, however, 9:00 pm cortisol, 10:00 pm cortisol, is well known to be associated with depression and other aspects of mental health, or I should say mental illness. So if you do need to be awake at night or even all night, red light is going to be the preferred light source. And in terms of how bright to make it, well, as dim as you can, while still being able to perform the activities that you need to perform. That's going to be your best guide. I'll provide a link to this study as well. Again, it's a really important study because it emphasized that there are forms of light, red light, provided it's dim, that can allow you to stimulate the alertness that light landing on the eyes can provide. So it allows you to stay awake and to do whatever work that you need to do. It does not seem to alter melatonin production, so that's good. It does not seem to alter levels

## 02:08:35 Light Flicker Phototherapy & Neuroprotection

or timing of cortisol production. So yet another case where red light used correctly can be beneficial. Up until now, we've been talking about the effects of shining different wavelengths of light on the skin or on our eyes and the downstream health consequences of that illumination. However, one of the most important goals of science and medicine is to figure out how to change the health of our brain. And of course, our brain is contained within our skull, and therefore we can't just shine light onto the outside of our head and expect it to change the activity of neurons deep within the brain, unless those neurons are linked up with our eyes or with our skin. And as it turns out, even though there are a lot of brain areas that are connected through neural circuits and hormone circuits through our eye, and believe it or not, also to our skin, many brain areas are not. Brain areas such as the hippocampus, which is involved in learning and memory, brain areas such as our neocortex, well, some areas of our neocortex such as our visual cortex are indirectly linked to our eyes, so if we shine light in our eyes, we can change the activity of neurons in our neocortex, but there are other brain areas that are not directly or even indirectly connected to our visual system, not at least in any immediate way. So that raises the question of how do you change the activity of neurons in the brain? Well, there's pharmacology. You can take pills, you can inject drugs that will change the pharmacology of neurons and the way they operate and fire. Of course, antidepressants are one such instance, opioid drugs are another. There's a huge array of psychoactive compounds, meaning compounds that will change the levels of chemicals in your brain. Some of those work, many of them also carry side effects. It's all rather indirect, meaning you have lots of different cells in different areas of your brain that utilize the same chemicals. So a drug, for instance, to increase serotonin for sake of improving depression will also often have the effect of reducing certain neurons output of serotonin in the hippocampus and cause changes in appetite or changes in libido and so on and so forth. You could imagine using electrical stimulation, putting wires into the brain and stimulating specific brain areas in order to activate the neurons in those brain areas. And certainly that works and has been done experimentally and is done during neurosurgery exams, et cetera, but involves removing a piece of skull. So that's not very practical. In principle, light would be a wonderful way to modulate the activity of neurons deep within the brain. But again, the skull is in the way. Recent studies, however, have figured out ways that light can be delivered to the eyes to change global patterns of firing

in the brain in ways that can be beneficial to the brain. And the work that I'm referring to now is mainly the work of Li-Huei Tsai at MIT, Massachusetts Institute of Technology, and her colleagues. And what they've discovered that there's a particular pattern of brain activity called gamma activity. Gamma activity is one so-called wavelength of electrical activity in the brain, so not wavelengths of light, but wavelengths of electrical activity in the brain that can be restorative for certain aspects of learning and memory and can actually help create molecular changes in neurons that lead to clearance of debris and even reductions in age-related cognitive decline. So the way to think about brain waves and brain oscillations is that neurons are electrically active, that involves chemicals, et cetera. And they can be active in very slow, big waveforms. So you can think of, you know, Delta waves, meaning, so you can imagine a wave of electrical activity that comes along very infrequently. So a given neuron fires, and then some period of time later fires, and then some period of time even later fires. Or you can imagine that that same cell is very active, fires, fires, fires, fires, fires. You can imagine if it's firing very often, it's going to be short wavelength, right? Shorter gaps between firing. Or if it's firing very seldom, you're going to think about that as longer wavelength firing. Turns out that gamma waves are one pattern of firing that lead to downstream metabolic functions and biological functions that end up clearing away debris that's associated with aging in cells and that also lead to molecular changes that enhance the kind of youthfulness of neurons, so to speak. How do we induce gamma oscillations within the brain? Well, what Li-Huei Tsai and colleagues have beautifully shown is that by delivering certain patterns of light flicker, so lights going on and off at a particular frequency, the brain as a whole starts to entrain, meaning it matches to those particular patterns of light flicker, even though many of the brain areas that do this are not directly within the visual system or visual pathway. So the studies that I'm referring to are several, but the one that I'd like to highlight is entitled, Gamma Entrainment Binds Higher-Order Brain Regions and Offers Neuroprotection. What they essentially did was to expose subjects to 40 hertz, which is a particular frequency of illumination, to the eyes. So it's light goes on, light goes off, light goes on, light goes off at a frequency of 40 hertz. And when they did that and they recorded the activity of neurons within the brain, not just within the visual areas of the brain, but within other areas as well, they observed increased gamma oscillations, meaning that the electrical activity of the brain at large started to match to the patterns of light that were delivered to the eyes. This is really exciting and very unique from the different types of phototherapies that we've been talking about up until now. All the

patterns of phototherapy that we've been talking about up until now involved constant illumination with a given wavelength. Here, it is wavelength generating patterns of illumination, light on, light off, light on, light off, at a particular frequency. So what they found, for instance, using this pattern of stimulation, and by the way, the stimulation was called genus, gamma entrainment using sensory stimulation, so G-E-N-U-S, gamma entrainment using sensory stimulation, had a number of really interesting effects. First of all, it reduced so-called amyloid plaques and phosphorylated tau. Amyloid plaques and phosphorylated tau are associated with Alzheimer's and normal age related cognitive decline. So this is incredible, right? A pattern of flashing light delivered to the eyes creates a pattern of neuronal firing, not just in the visual areas of the brain, but in other areas of the brain as well, that in turn trigger molecular pathways that reduce some of the markers and the cause age-related cognitive decline in Alzheimer's. And in parallel to that, they observed an upregulation of some of the biological pathways that lead to enhancement of neuronal function, maintenance of synapses, which are the connections between neurons, and so on, and so on. They have discovered and list out a huge number of these biological effects, both the reduction in bad things, so to speak, and the improvement in good biological pathways. And I find these studies so exciting because, first of all, they're non-invasive, right? There's no drilling through the skull. They are very tractable in the experimental sense, meaning that you can imagine that if 40 hertz stimulation turns out to be the very best stimulation protocol to induce these gamma oscillations, well, great, but because it's non-invasive, it's fairly easy to explore 50 hertz stimulation, 100 hertz stimulation, 20 hertz stimulation, and to do that with different wavelengths of light. And so that's what's happening now. The Tsai lab and other labs are really starting to explore the full range of variables that can impact oscillations within the brain and their downstream consequences. So again, this is phototherapy, but phototherapy of a very different sort that we've been talking about up until now. It's phototherapy designed to trigger activation of biological pathways far away from the very tissue that's being illuminated. And it calls to mind the same sorts of mechanisms that we were talking about earlier, where illumination of the skin with UVB light is setting off an enormous number of different cascades in different organs and tissues, including the spleen, the testes, the ovaries, and so on. So again, light has these powerful effects, both locally on the cells that the light is delivered to, but also systemically in terms of the cells that are changing their electrical and chemical outputs, are modifying lots and lots of biological programs. Is there an actionable tool related to these studies yet? Well, that

sort of depends on how adventurous you are. Right now, these studies are being explored in the context of clinical trials, in people with Alzheimer's, dementia, and other forms of neurodegeneration. Is it dangerous to look at a 40-hertz flickering light? Well, in general, the answer is going to be no. However, if you're prone to epilepsy, for instance, staring at a flickering light of a given continuous frequency can induce seizure, right? That might surprise some of you, but it shouldn't, because as this study illustrates and as anyone who's ever been out at night to a club or something illustrates, when you look at a strobe light, for instance, your whole world of visual perception changes, but actually, the rhythm at which you perceive music, at which you perceive conversation, at which you perceive the movement of your body actually changes according to the patterns of visual flicker, in most cases, strobe, if we're using the sort of club dancing example. Your brain is in training to its outside environment. So given the power of flickering lights to entrain brain rhythms, I think at this stage, it's probably too preliminary to really suggest a specific protocol, but I would definitely keep an eye out for these sorts of studies. They are coming out all the time. And I think in a very short period, we are going to see specific protocols that one could use even at home, and of course, these are non-invasive protocols, in order to place the brain into a particular state, not just for sake of offsetting neurodegeneration, but also for enhancing focus,

#### 02:19:07 Phototherapies for Health

for enhancing the transition into sleep, and other brain states as well. Today, I covered what I would say is a lot of information. My goal was to give you an understanding of how light can be used to change the activities of cells, organelles within those cells, entire organs, and how that can happen locally and systemically. We talked about the power of light to impact our biology at the endocrine level, neuronal level, immune level, mood, et cetera, through both illumination of the eyes and the skin and other tissues as well. I realize that even though this was a lot of information, there are many aspects of phototherapy that I did not cover. I know there's a lot of interest nowadays, for instance, in the use of red light and other wavelength light therapies for ovarian health and testicular health. In fact, I get a lot of questions such as, can red light be used to improve testosterone output? And if so, is that best accomplished by shining red light on the skin or directly on the gonads, on the testicles? I'm going to cover those data at a future time. Right now, the studies that have been done in rodents, I don't think are easily enough

translated to humans. And the studies that are happening in humans now are exciting in the sense that they hold a lot of potential, but the data aren't clear yet. However, the data using UVB on the skin of men and women in order to increase hormone, in particular testosterone and estrogen output, those data, I think, are very exciting and very actionable when we talked about those earlier. So if you want more information on how phototherapy can be used,

02:20:50 Zero-Cost Support, YouTube Feedback, Spotify Reviews, Apple Reviews, Sponsors, Patreon, Thorne, Instagram, Twitter, Neural Network Newsletter, Brain-Body Contract

certainly we will do another episode on phototherapy in these other contexts. If you're learning from and are enjoying this podcast, please subscribe to our YouTube channel. That's a terrific zero-cost way to support us. In addition, please subscribe to the podcast on Apple and Spotify. And on Apple, you have the opportunity to leave us up to a five-star review. If you have questions or feedback or comments or suggestions about topics that you'd like us to cover in a future podcast episode, or guests that you would like me to interview for the Huberman Lab Podcast, please put all those suggestions, comments, and questions in the comments section on YouTube. We do read all the comments. In addition, please check out the sponsors that we mentioned at the beginning of the episode. That's the best way to support this podcast. In addition, we have a Patreon. It's [patreon.com/andrewhuberman](https://patreon.com/andrewhuberman). And there, you can support the podcast at any level that you like. During today's podcast, we didn't really talk about supplements, but we do talk about supplements and their various uses in many other episodes of the Huberman Lab Podcast. While supplements aren't necessary for everybody, many people derive tremendous benefit from them. For that reason, we've partnered with Thorne, T-H-O-R-N-E, because Thorne supplements are the very highest quality and stringency. If you'd like to see the Thorne supplements that I take, you can go to [thorne.com/u/huberman](https://thorne.com/u/huberman). And there you can get 20% off any of the supplements that I take. And if you happen to navigate deeper into the Thorne site, through that portal, [thorne.com/u/huberman](https://thorne.com/u/huberman), you can also get 20% off any of the other supplements that Thorne makes. If you're not already following us on Instagram and Twitter, please do so. It's [hubermanlab](https://www.instagram.com/hubermanlab) on Instagram. It's also [hubermanlab](https://twitter.com/hubermanlab) on Twitter. And at both places, I provide science and science-based tools, some of which overlap with the content of this podcast, much of

which is unique from the content of this podcast. If you're not already subscribing to our newsletter, you might consider doing so. It's the so-called Neural Network Newsletter. You can find it at [hubermanlab.com](https://hubermanlab.com). Just go into the menu, look up Neural Network Newsletter. You provide email. It is zero cost. We provide summaries of podcasts, summaries of actionable protocols and so forth. We do not share your email with anybody else, and we have a very clear privacy policy there at that website if you choose to explore it. I'm also pleased to announce that we have some live events coming up. So I will be giving a lecture called the Brain Body Contract, where I'll talk about science and science-based tools, some of which overlap with the content of the Huberman Lab Podcast, much of which is unique and has never been presented publicly before. The first one is going to be May 17th, 2022 in Seattle, Washington. The second one is going to be May 18th in Portland, Oregon. To access tickets, you can go to the link at [hubermanlab.com/tour](https://hubermanlab.com/tour). So thank you once again for joining me today for this deep dive discussion into phototherapies, meaning the power of light to modulate our biology and health. And as always, thank you for your interest in science.