Announcer: Bulletproof Radio, a state of high performance.

Dave: You're listening to Bulletproof Radio with Dave Asprey. Today's cool fact of the day is that a lack of sleep can induce anxiety. In healthy adults, well at least they said there healthy, overnight sleep depravation triggered anxiety the next morning along with altered brain activity patterns. People with anxiety disorders oftentimes have trouble sleeping, and these new results show the reverse effects that poor sleep when you have it can induce anxiety.

Dave: This came out of UC Berkeley and they looked at 18 people following either a night of sleep or a night of staying awake, they did anxiety test the next morning. Sleep depravation led to 30% more anxiety than people who slept. The anxiety scores reached levels of people who have anxiety disorders and sleep deprived people's brain activity changed too.

Dave: When they looked at emotional videos brain areas involved in emotions were more active. The prefrontal cortex, which is the part of you that helps you think and pay attention, sort of the thinking human, is also the party that slows down your anxiety, that part was less active. This is according to functional MRI scans. So poor sleep isn't just a symptom of anxiety, but maybe it's a cause. That's a definite call to hack your own sleep, which is particularly important.

Dave: Something that wasn't in the study that's really interesting too is that your gut bacteria also have their own separate circadian rhythm. So when you stay up all night or you're jet-lagged, your gut bacteria are also jet-lagged and when they get pissed off, guess what they do? They make something called LPS or lipopolysaccharides, a very potent toxin that crosses the gut barrier and especially if you don't have [inaudible 00:01:55] lining, causes inflammation throughout the body including in the brain.

Dave: LPS is bad news and this is one of those reasons if you're going to stay up all night, take some charcoal already because charcoal binds LPS. You'll feel better the next morning, and you'll have less anxiety. Who would have thought?

Dave: You may have noticed in my continuous evolution of becoming great at foreshadowing that we might talk about sleep and circadian biology in today's episode. There's a couple of reasons for that. One is I'm a huge fan of understanding and learning and knowing what's going on there because it's one of the things that's led me to perform better.

Dave: It's one of the core things that showed up in the Game Changers book in the study of the laws of high performers, these 46 laws that came out from almost 500 episodes of Bulletproof Radio. Just studying with the [inaudible 00:02:46] what are the common patterns that people talk about as being most important for them to reach the level of attainment in their life or in their career to have done something noteworthy that is worth getting on the show. Well, sleep was up there. In fact, it's in law 19.

Dave: That is why today I'm really happy to have a friend and former guest of Bulletproof Radio back on the show. I'm talking about none other than Satchin Panda, PhD who is a

leading expert in circadian rhythm and a professor at the Salk Institute in San Diego. He has written an app called myCircadianClock that helps you synchronize your circadian biology.

Dave: His lab has been transformative because he's shown the profound impact of ambient light in daily eating fasting on preventing huge numbers of diseases like diabetes, depression, metabolic syndrome, heart disease, cancer, and stuff like that. He's also come up with this concept of time restricted eating. It's very related to intermittent fasting, but he says that people who eat everything within an eight to 12 hour period can boost their circadian rhythm and maybe even reduce chronic diseases.

Dave: So in February of 2018, Dr. Panda was on Bulletproof Radio in two different episodes. If you didn't pick up his book about this when you heard him on those two last episodes, number 466 and 467, you need to pickup the Circadian Code, which is a really good overview of this. Circadian biology is tied into my work since I first read a book in 2001 from T. S. Wiley called Lights Out: Sleep, Sugar, and Survival. Her work set off my path of circadian biology.

Dave: When I got to meet Dr. Panda at the Salk Institute a couple of years ago and got into his lab and look at rat melanopsin [inaudible 00:04:44] PhD researchers, I'm like this guy is changing the world, which is why he's on for his third time. Dr. Panda, welcome to the show.

Satchin: Thank you, Dave. That was really nice introduction. I'm really flattered that you are such a big fan of circadian rhythm and everybody certainly because as you said, that's one of the foundations of better health.

Dave: Right before recording this episode, I was at the American Academy of Antiaging Medicine. I gave a keynote talk and I mentioned you and your work on stage in front of thousands of antiaging doctors. Then later I was on a panel with Peter Attia who's also been on the show. Peter and I on our panel both mentioned your work separately.

Dave: So you've made great inroads with this huge audience of people out in the trenches working with patients on making them younger because circadian biology is one of those things we just didn't know anything about, I would say 20 years ago [inaudible 00:05:46] anything relevant. It's completely change things. Why are we finding all these changes just it in the period of time of your work? What happens to make us come more aware and to the crack the code, given that's the title of your book?

Satchin: Well, circadian biology is a very interesting aspect of biology. If you think about ever other field of biomedical research, there's a disease and then people work on the disease. Circadian rhythm started as a very simple curiosity, why we go to sleep, why we sleep for seven hours or eight hours, and is there a clock inside?

Satchin: What happened is in the last 20 years, the key discoveries can be summarized into three major things. One is people discovered that just like our brain, almost every organ has its own clock. That completely transformed how we think about circadian clocks. The

second one was we also figured out that blue light is a strong agent in sunlight that resets our clock of having exposure to blue light at night can disrupt the clock. The deterred measure discovery was how food timing affects our clock.

Satchin: So these three really transformed how we think about health because if you think about now what circadian rhythm field is doing, this is the only field that's actually studying what is health because all of the fields of biomedical research study what is disease. So, we can go over this three major discoveries or breakthroughs in circadian rhythm field.

Satchin: The first one is every organ has its clock. That's a profound statement because if we think about clock, we always think about sleep. So that means just like our brain has a clock that tells our brain to sleep for seven to eight hours at night, it also tells our brain that the peak time to do complex math, have complex business negotiation or solve problem is somewhere say between 8:00 AM and 2:00 PM.

Satchin: So that means if other organs have clock, they should have their optimum time to do their job, they also need downtime to rest, reset and rejuvenate. Slowly, over the last 20 years, people working in this field are finding out yes, that's true. Just like our brain has a clock, liver has a clock and it can digest food and can nurture our body for only seven to eight hours or maximum say 12 hours and that it needs downtime. Similarly, our gut has a clock. Even the microbiome that lives inside the gut, they have a circadian clock or a daily clock. Muscles have a clock.

Satchin: Now if we think of our health, our health is a product of our organs and hormones. When our organs, hormones, and brain chemicals rise and fall at the right time, then our body clock synchronize and we are at top performance. That's a very profound concept that's evolving in circadian rhythm field.

Dave: Okay. You mentioned the liver quite a lot in there and it's funny. People oftentimes don't associate circadian things and sleep with what the liver is doing. Tell me more about why you brought that up.

Satchin: Well if you think about the liver is one of the largest solid organ that is very important for metabolism. So it produces fuel for almost every part of our body, including brain. It also breaks down a lot of synbiotics or unwanted molecules that we ingest. This is also place where we produce many of the key molecules for fighting infection. So liver plays a huge role in our health.

Satchin: In fact, interestingly, most of the circadian studies these days have moved away from looking at the brain and they're more and more looking at the liver since liver plays such a big role. For example, if we think about fasting, then liver is the major place where our liver produces some ketone bodies towards the end of our 14, 16 or 18 hours of fasting. That ketone body is transported to our heart and brain for better function. In that way, liver plays a huge role in purring our brain and keeping us smart.

Dave: It really matters so much. One of the studies that I was really pleased to see that came out of UC San Diego was Dr. [inaudible 00:10:49] research that showed the amount of

caffeine into small cups of coffee doubled ketone production. So let's say I just slept all night, which is a fasting window unless you sleep eat. Then all of a sudden you wake up and you want to get some more of those ketones that will happen if you skip breakfast. But if you have black coffee, you're going to have more ketones than if you didn't according to that study.

Dave: Of course if you're doing Bulletproof Coffee where you have brain octane in there, you can be sure you're getting some extra ketones in the morning. For me, that's just been a profound awakening of my brain given that I used weigh 300 pounds and had autoimmunity things and high blood sugar and prediabetes and all the other crap that I had to deal with when I was younger.

Dave: So it's no wonder that the liver matter, but if you look at traditional Chinese medicine, [inaudible 00:11:42], and all these eastern systems of healing, a lot of them are heavily focused on liver and kidneys. Of course, they care about the brain, but it seems like we're now using circadian biology to rediscover things that maybe we knew it a thousand years ago. Do you agree with that?

Satchin: Well, the thing is when it comes to health and wellness, anything that we can think of has already been tried in human history because humans have been trying by trial and error and many other methods to figure out what is the best way to live a healthy long life. So that's what we always hear that yes, whatever you discover our grandmother used to say.

Dave: Well, that was definitely one of the laws in the book. Eat like your grandmother is one of the laws in the book, which is also tied to mitochondria, the assumption. I thought I'd test this on you. So when I interviewed all the people in Game Changers and I said that question on Bulletproof Radio top three recommendations for people who want to perform better at everything, I ended up having some sort of weird thoughts on that and saying all right.

Dave: Number one data point that came out was food, but certainly not everyone agrees on what to eat. But everyone agrees if I eat the wrong stuff, I can't show up. I'm not going to be a game changer if I eat garbage. I think there is an algorithm for eating and the Bulletproof Diets worked very well. It's an algorithmic approach that says eat less of the stuff that makes you weak so you're less inflamed. Eat more of the stuff that it gives you energy and more nutrients et cetera, et cetera, but [inaudible 00:13:24] to put them on the map.

Dave: But when you look at mitochondria, they come from the mother's side. So, it's what your mom's, mom's, mom's, mom's, mom's ate. Your mitochondria are going to be adapted for "your people". So if you're to flip a coin and say will I handle legumes? Will I handle nightshades? Will I handle dairy? Will I handle those things?

Dave: It is more likely that since your mitochondria or the things that turn air and food into electrons at the end of the day, it's more likely that if you look at what your ancestors ate on that side, you'll get some hints as to where you might want to start when you're

figuring out what's going to work for you. Do you buy that line of reasoning? It's okay to say no, but it seems to work.

Satchin: Well the thing is we always think of okay, there's epigenetics that is inherited from our ancestors. But at the same time, if our ancestors went through famine or fasting or maybe too much food, a certain type of food, and that's imprinted in their gene or mitochondria as you know, then that is also a good sign that if we change our behavior we'll also imprint our mitochondria or our genome in a very different way. And we can pass on that mitochondria or that epigenetic code to our children.

Satchin: In that way, it's an interesting hypothesis. People always say that whatever your parents did that is imprinted on you and the flip-side of that coin is if you pick up some good habit, you'll also pass on those good habit to your children. If you become some bad habits, that's also going to pass on to your children.

Dave: Yeah. I've become more and more convinced from reading literature and just from writing Head Strong, my last big book. If you look at what the first-line environmental sensors for epigenetic sensing are it appears to be the mitochondria. That they're the ones who would make up a single cell decision about allocation of resources, more so than other subcellular structures.

Dave: And saying all right, if they're one of the things that controls epigenetic switching, and I found a couple studies that indicate that that's probably how it works, that if you look then at what are they most wired for? If your mother let's say was born at the equator eating a relatively high starch diet and then you, in one generation, moved to the North Pole and tried to go to an Eskimo diet, you're probably not going to like what happens biologically, right?

Dave: But if over the course of your walking across the land bridge over thousands of years to allow epigenetic changes to percolate through your genome and you crossbred with some other people along the way, it's fine. You are probably going to be able to handle the North Pole a little bit better. It's that idea that says, yes there will be [inaudible 00:16:26] changes, and yes the father's DNA, which goes to the nuclear genome probably makes a difference here.

Dave: However, if you were to close to your eyes publicly and say okay, when am I most likely to have this compel my biology? Just look at your mom's history and start there and then see what else works. That was the general thinking behind it.

Satchin: Well, the thing is mitochondria genome encodes only 13 or 14 protein in the mitochondria, but more than 1200 genes that instruct the mitochondria to function or build up the mitochondria that come from the nucleus. That's where both mothers and fathers genes play a big role.

Dave: That's correct.

Satchin: Also, there is epigenetic imprinting that will happen, more likely to happen among these few of these 1200 genes. So that's how yeah-

Dave: In the nuclear-

Satchin: ... nuclear genome.

Dave: ... DNA. So what got me thinking about these lines was a fascinating study and if you haven't seen it, stop me so we won't go too deep on it. But they were looking at starlings I believe, some sort of small bird, it might have been a different one. The population spread a couple of years ago. Half of them live outside Canby and half of them live outside Portland. Over that time, their mitochondrial DNA mutates to help them be more optimized for the Pacific Northwest versus the sunshine.

Dave: Well, researchers took these two populations aside and wondered if they can crossbreed. So, they crossbred them and they found that the offspring had relatively high degrees of chronic illness. They said well this is a mismatch between the nuclear DNA and the mitochondrial DNA and that the wiring diagram didn't match the physical infrastructure. Those 1200 genes didn't line up very well with the mitochondrial DNA.

Dave: But when they took the kids and then they crossbred the chronically ill offspring with the other side, their often were healthy. So, they turned this on and off by aligning the nuclear DNA and all. Have you come across that study at all in your research?

Satchin: No, I haven't. I should look up that study to see.

Dave: It's very interesting because all of us as humans, 99% of us have huge amounts of crossbreeding where you look back and [inaudible 00:18:50] says, "Oh Dave, in the 1700s, you have a full-blooded Native American ancestor." I'm like, "We had a family legend that might be case, but we had no data. So okay, apparently that was true." I don't know what that means but it means that there's no such thing as a perfectly match mitochondrial DNA to nuclear DNA. But I think that may be affecting chronic illness and it seems like probably stuff that's hackable. So it's a fascinating world, but you haven't gone down that path in your research.

Satchin: Yeah.

Dave: Okay.

Satchin: No. What we know is the mitochondria they repair themselves and divide and fuse together, so this happens on a daily basis. There's a circadian rhythm to that. So the mitochondria will divide and then will get rid of the bad portion of the mitochondria. Then the good mitochondria will fuse together to make good mitochondria.

Satchin: Having a strong circadian rhythm helps nurture this cycle of rejuvenation of mitochondria on a daily basis because if we accumulate those mutations in mitochondria DNA, then even though we have 1200 genes and the nucleus that

constitute the mitochondria, this tiny part of mitochondria DNA if that is mutated then that can cause a lot of problem. So it's a nice mechanism to divide, get rid of the bad mitochondria and then fuse again. That's strongly driven by circadian rhythms.

Dave: Well, let's talk a little bit more about circadian rhythms. Sleep came up very high on the things that high performers do in Game Changers, and it led me to create a law 19 in the book. The title of law 19 is Waking Up Early Does Not Make You a Good Person. The subtext for that is, there's no morality in waking up early or staying up late. There's a huge amount of power in finding out when you sleep best and building your life so you can sleep then.

Dave: The point for that is that one of the other laws is what you do in the morning really does matter. So the miracle morning perspective from Hal Elrod, but that the definition of morning for an early riser is different than the definition of morning for a late riser. And that knowing when to sleep seems like an important thing to discover so you can show up all the way. Talk to me about what you've seen either in the lab or in other readings, other research around proper wake up time and is it the same for everyone?

Satchin: Well, your day actually begins when you go to bed the previous night because that determines how long you'll sleep, how long you'll reset your brain and then how fresh you'll wake up in the morning. One rule of thumb is most sleep researchers agree that an adult should be in bed for eight hours. I'm saying should be in bed for eight hours. Out of that, somebody may get six and a half to seven hours of sleep. So that means if someone wants to wake up at 6:00 AM, then this person should aim to go to bed at 10:00 PM at night.

Satchin: Then the question is whether people who wake at 6:00 AM versus 8:00 AM, 9:00 AM or 10:00 AM are there any difference in performance? I think that's where the wake up time is not as important as how many hours you slept. The person may be going to bed at 3:00 AM and waking up at 6:00 and maybe getting three hours. We know that that's not going to work very well for next day's performance.

Satchin: But when people wake up late then the thing is they're more likely to have a better night sleep because what is happening is in modern days, we have to stay awake late into the night for many different reasons. We have to have a social life or sometimes the kids come back. The parents help them with homework or something else. So in that way, our sleep is getting derailed, and people who wake up later maybe they're getting better sleep.

Satchin: One nice study on that not on older adults, but on high school students just came out. It's a nice collaboration between Horacio de la Iglesia from Seattle and our lab. What happened was few years ago, there was this hypothesis that teenagers are not getting enough sleep when they wake up in the morning and go to school very early. So maybe delaying their school's start time will help them.

Satchin: So Seattle School District, which is the largest school district in the U.S., decided to delay the high school start time from 7:30 in the morning to 8:30 in the morning. There was a

big resistance from teachers because teachers and parents they are likely to wake up early and teenagers are likely to wake up late. So that's why Seattle School District was very eager to see whether the late school start time has a better effect on students' performance.

Satchin: Horatio and his team monitored 200 students from two different schools when the school start time was 7:30 AM. They monitored them with very high grade. There's FDA approved medical grade sleep trackers and activity trackers up to 75 days, for up to almost two months before the school start time changed and also tried their grades and tried their absenteeism or tardiness. Then after the school start time changed to 8:30, he again went back and collected the same set of data from 200 students. Then the results are pretty clean.

Satchin: Over the last 100 years, U.S. adults and teenagers have lost one hour sleep. So that means in every year, we're losing around 406 minutes of sleep. What he found is by delaying school start time by an hour, these students got 34 minutes of sleep. So that means we turn the clock back among Seattle school students. So that now in 2018, these students are sleeping as much as students in 1950 were getting that much sleep.

Dave: I'm so happy that you're talking about this. I am always talking about school start times on social media. Here's the thing. It's torture to make any animal wake up way earlier than its supposed to five days a week for basically 12 years. That's definition of school right now. I'm actually looking at moving my kids' school to one of the latest start time because the amount of time they will live is based on the sleep quality they get as kids. I'm going to buy them another 10 years of healthy longevity just by getting them out of these like wake up early things.

Dave: This is one of the things that also drives people to start homeschooling and things like that is you don't want to have your kids getting up at 6:30 in the morning when they're 14 years old. It's not natural. It's mean.

Satchin: Not only that, we also saw that when they slept more 34 minutes, it's not that they don't do their homework. Actually, they improved their grade by nearly 5%. Just imagine, if your kid is getting 86, 87 in all the subjects and is getting a B grade, just that extra sleep will bring that grade to A because now he or she is going to get all As and the average score will be around 90, 91. We also reduction in tardiness particularly if kids when they're getting up too early and then they're sleepy and there's not enough time to reach school. A lot of them end up being late.

Satchin: So this is an exciting study that clearly shows that in modern days it's not ideal to wake up so early and maybe for some people, at least for high school students who are the foundations of our future, we should let them sleep a little bit more. It's going to improve their overall healthy, increase maybe longevity in long-term, improve productivity and their score.

Dave: Well, I am going to take the excerpt of this interview and I'm going to a play it for the school board here. I would encourage you, if you're listening to this, to take as we got

Dr. Satchin Panda, one of the world's preeminent experts from the Salk Institute on circadian biology telling you that sleep is a cognitive enhancing substance. You can use your kids to get better grades, get them to shove the school more. So, there's no excuse for starting school early.

Dave: You've heard these dumb excuses like, "Oh, it impacts traffic flow." It's like hey, this is the next generation here. So go around the school zone or something. It doesn't matter that this is simply not okay. I think it's one of those things that we're going to figure out multiple generations wise. Let's see what happens when you have five generations of people who are sleep deprived as kids, what it does to the IQ of a country. Probably not good things. All right. I'll get off my whistle box there.

Satchin: So you pointed out one thing, traffic flow. Actually, there are studies showing that when school start time is delayed, then the kids have less accidents.

Dave: Of course because I remember driving like a zombie to school what I can remember from my school because I was so darn tired because they made me wake up in the middle of the night but all right. I have another question though. You mentioned most sleep experts agree on eight hours of sleep, but most exercise experts now will also tell you that they agree on 10,000 steps as the ultimate number of steps per day.

Dave: Now, I did some digging on that a while back for the Bulletproof blog. The number 10,000 steps came from a Japanese company that invented the first pedometer, a mechanical pedometer put on your belt in the 1950s. So, they just made up the number from thin air and told everyone in marketing that 10,000 steps was the ideal. To this day, we will swear up and down the 10,000 steps is a magic number. It is not a magic number.

Dave: When I looked at the data on sleep and found that the people who live the longest from a 1.2 million persons study that went for three years that they only sleep six and half hours a night. I'm like I don't care if most sleep experts say that you should sleep eight hours a night because it's apparent that sleeping more than eight hours a night is actually dangerous compared to sleeping maybe seven and a half hours. So where does eight hours really come from, and do you believe that having seen rat melanopsin sensors in labs and Petri dishes and all that? How much BS are we dealing with?

Satchin: Well, the epidemiology is right. The cells report a six and a half hour of sleep correlates very well with longevity or light history life. When it comes to eight hours, it's not eight hours of sleep. It is eight hours in bed. That's what I always tell people that-

Dave: So it's what else you're doing in bed that makes you live longer. Okay. That changed the whole equation.

Satchin: Yeah. When I say, I always tell people aim for eight hours in bed. We know these days when people go to bed, they're checking emails and doing other things. Then when they wake up, sometimes they wake up and then they're still tired. They check their email

and other stuff before they get out of the bed. That's what we say that target eight hours in bed.

Dave: Okay. Eight hours in bed no matter what you're doing. I might be able to get away with that. The other obvious thing there is if you can reduce sleep latency and this is a measure of how long it takes you to fall asleep. Think about this. My sleep latency is usually under three minutes because there's breathing techniques and other stuff like that. I've done enough neurofeedback. The voice in my head is generally pretty quiet. I lay down, close my eyes and say go sleep and then I'm out. I can do that whether or not I'm super tired or not. So, I don't think it's sleep depravation that does that.

Dave: But imagine if you took 20 minutes, that extra 17 minutes of your life every day for the rest of your life, this is one of those things that you must hack that because 17 minutes is enough time to do high intensity interval training that day and still have more time. It's a really big savings. Do you have anything you've learned from all the work you've done specifically with lighting or food or anything else about reducing sleep latency so people go to sleep faster when they want to in bed?

Satchin: Well, there are few things. I see you've already hacked how to do your neurofeedback. One thing is what we're finding people who do time restricting eating and particularly they stop eating two to three hours before bed time, that helps. Second, reducing exposure to blue light for two to three hours before going to bed that also helps. This is much more important because now, actually I have a app that we just built up from the lab called myLuxRecorder, one single word and wherever I go-

Dave: Can I get now? Is it on Apple store?

Satchin: Yeah. It's on iOS.

Dave: And it tracks your light exposure all day? I've been wanting this for years.

Satchin: No, no. It's not. You have to open the app and then record it, but then the point is wherever I go, I just record it. What is interesting, two to three years ago when LED lights were not that popular, many stores, department stores, grocery stores, drug stores et cetera, they used to have 300 to 500 lux of light. Now after the switch to bright blue LEDs these stores have easily 1000 lux or more of light. That is very worrisome because most people go to do their grocery shopping or go to get a drug from the drug store at night. When they go, they spend at least half an hour in this bright blue light.

Dave: Yes.

Satchin: So one more thing to add is if you're going out of your home and going to a drug store or a grocery store or any store these days, then make sure that you're less exposed to blue light. Maybe this is where blue filtering glasses will come in handy and many cases we cannot just stop going to these stores at night. That's the only time we may have to go shopping.

Dave: Okay. That's [crosstalk 00:33:33]-

Satchin: So no food for two to three hours. No bright light for two to three hours. Then some people their cold body temperature or body temperature doesn't fall well at night time and to have a good night sleep, we need to have a good drop in cold body temperature. So people can take a shower and that actually helps to drop the body temperature they can go to sleep.

Dave: A cool shower.

Satchin: Yeah. Some people like warm shower, some like cold shower. But the bottom line is, whatever shower you take, your blood circulation will draw towards your skin away from the core and that helps to cool down your body.

Dave: Will drinking a glass of ice water be a good idea before bed?

Satchin: Yeah. If you're not likely to get up and pee, then that is a good idea.

Dave: Okay. Fair point. That's bad for sleep. Peeing is bad for sleep. Got that one.

Satchin: Then the last one is your right to darkness because we have lost our right to darkness. There's so much light everywhere. It's really sometimes mind-blogging how we have lost our right to darkness. Even in a modern house with the best architecture, without good I mean-

Dave: blackout shades.

Satchin: Yeah, good insulation or good dark out curtains, it's almost impossible to get darkness. Plus there are these indicators and all these lights on your phones, on your appliances, TV, et cetera. So that keep up very jazzed up. In fact, there is a study that just came out showing that even one lux of light, which is equivalent to event bright moonlight on full moon night, having that one lux of light in some bedroom for some people can disrupt their sleep. That's why it's very important to have right to darkness. If you cannot have darkness, then maybe a pair of eye seals or sleeping mask will help.

Dave: There are also studies that came out in 1998 that help to drive some of my sleeping hacking experiments that I think have been widely echoed on the Internet now around blacking out the room because the study in 1998 looked at the red and blue light on the back of the knee and found that it affected sleep. They did a really good thing behind the sham light. It was blinded. It was a properly done study and they found changes in REM sleeps. People got less deep sleeps and more REM sleep from light exposure on skin.

Dave: The talk that I gave at the American Academy of Antiaging Medicine I talked about the effects of blue lights specifically on parts of the eye that aren't the melanopsin receptors that control circadian rhythm. It's just on corneal thickness and all, but it's also affects the skin by creating free radicles in the local circadian timing of the skin. If you have blue

light on the skin while you're sleeping with a night mask, the skin is still going to say oh, it must be day time and things like that. So an eye mask yes.

Satchin: Actually, Dave maybe I should correct you there because that particular study about the behind the knee has been proven wrong.

Dave: Oh, do tell. I have not seen an update on this. Okay. Tell me all about.

Satchin: Yeah. So that actually came out almost 10 years ago, because the behind the knee was 1999 or 2000 and those guys the biggest flaw in that study was to keep these people awake, they had the TV on.

Dave: Come on, seriously?

Satchin: Yeah.

Dave: All right.

Satchin: I'll send you that study. This is from Ken Wright Jr. that also came out in science. They clearly refuted that that study is flawed and there are two other studies that came out and since then, no one has talked about skin light receptor.

Dave: But we have found that there is a skin circadian biology, like local organ systems in the body.

Satchin: Yeah, yeah. There is circadian rhythm in skin but that skin circadian rhythm is not directly sensitive to this dim light or blue light. Light might have different effect on skin, but that study has been refuted.

Dave: Okay. Thank you for telling me that. I did not see the refutation. I did see the original study and was blown away by it.

Satchin: Yeah.

Dave: What does concern me though is if you look at the correlation between fluorescent light exposure on the skin and melanoma and the correlation is higher from florescent light on the skin than it is from sunshine on the skin, which is not to say that getting sunburned is good for you. But it is to say that there's something going on with skin and light that is concerning to me. There's a photoaging effects from not just UV, but also from blue that may not be circadian, but just may be mitochondrial.

Satchin: Yeah. We also don't know what happens to violet light on skin. For example, now there are lot of violet light being used to decontaminate. So just like UV light kills bugs, there is a narrow band pass in violet light that can also kill bugs. There are new lighting in hospital and vivariums and doctor's offices now that a violet your eyes cannot figure out whether it's violet or not and that are used for disinfection. These are also in our food

supply chain. It'll be interesting to see whether that violet light which can kill bugs what are the types of effect it has on our skin?

Dave: Well, I like to our mitochondria, our ancient bacteria they probably are affected by that light.

Satchin: Yeah, that'll be interesting to see.

Dave: Yeah. I have to go that deep on things. Just if you're listening to this going how crazy is this stuff? People come to my house at night and they say, "Dave, why is it so dark in here?" I'm like "Because it's nighttime." Yes, there's red lights in my house. Every room, when I stay up late writing Game Changers and all, it's only red rumination. My monitor is set to red or I'm wearing the TrueDark glasses that are red.

Dave: I'm not kidding. It is dim and it is red like a submarine and you know what, my kids go to sleep at 8:00, 8:30. They sleep all night long. If they wake up to pee, the bathroom lights are red. They go right back to sleep. They do not have sleep issues. They never have had sleep issues. They sleep in blacked out rooms and they consider it normal.

Dave: Every LED light in my room is off because when I go to bed in addition to the blackouts curtain, I have a remote control that disconnects the wiring my room from the circuit breaker. Which means anything that had an LED light is now turned off for the night in addition to lower EMF. That's about an $800 remote control thing depending on how handy you are with a circuit breaker. You can do that stuff and your neighbors will think you're a vampire because of the red lighting. It doesn't matter. Your sleep quality is so good. It's worth it.

Satchin: Oh yeah.

Dave: Okay. All right.

Satchin: No, this is a very important issue because right now in many countries, the only bulb people can purchase is LED light. If they're not aware about how much light they need or how dim they need is going to make the sleep depravation and more profound and widespread. It'll be epidemic of less sleep because of the LED lights.

Dave: What do you do at home for sleep with your lighting?

Satchin: Well, we don't have any light that produces more than 40 watt of light. These are all dim. If we need lighting, then we have spot lighting or work lighting. For example, table lamps that illuminate the work area but not your eyes, not your face. Then all of my computers and smartphones they already have night shift or nightlight feature. So, they switch to orange color or dim down around 8:30 or nine o'clock. So that's one has to be very knowledgeable and has make that an extra effort, but it just extend to 15 minutes to change all your night shift or nightlight feature at least on your computer.

Satchin: It may not affect your sleep but at least it nudges you because you're staring at the computer and your computer screen changes, then you know that it's time to go to bed. So it acts as a going to sleep alarm clock. We have waking up alarm clock, but this light changes actually prepares your body and then slowly you'll fall asleep.

Dave: That is fantastic. Having a go to sleep alarm clock is profound and using light as a way to do that is really cool because most people listening probably on some Internet ad or something, you've seen the alarm clocks that we wake you up with light. They slowly turn on and then the light comes up and up and up before there's a sound alarm. So that when the sounds happens you're already mostly awake because the light signaled to your body hey, it's about time to wake up. Why not do the reverse when you go to sleep? I really like that idea.

Satchin: Yeah. I think slowly many of the building control systems will incorporate this idea. Just like your Nest thermostat cools down your home or warms it up before you get home, so similarly maybe all the lighting in the house will slowly dim down starting from the kitchen. Kitchen should close around 6:30 or 7:00, so kitchen should become dark, and then slowly the living room and then you'll be nudged to go towards your bedroom.

Dave: I love it and while we're at it, I'm just going to say manufacturers of TVs make it relatively annoying to dim the backlight on the TV, but dim it. So, as dim as it's comfortable during the day, and when we watch something after the sun is gone down, I screw around with the remote until we've got the backlight turned down to zero or one on a scale of 20 so that we're not staring at a bright super blue light source. The difference is very noticeable. We actually get less tired and stressed when you're watching TV anyway and it doesn't affect sleep as much.

Dave: These are things that are based on hardcore biology of what's happening in the eyes, but we're not aware of them. None of this is about what you eat, although you and I both are in agreement, circadian timing of food matters and eating windows. But the light thing is similar I think junk light is bad as junk food. Would you eat a big bowl of french fries? I would hope not. Would you stare at bright light LEDs right before bed? I'd hope not because it's kind of equivalent in terms of doing bad things for you.

Satchin: Yeah. It's almost like timing makes healthy food junk. Similarly, timing can make healthy light junk. During day time, we need that blue light or bright light but at night time, that's just junk light.

Dave: And even too much blue light during the day it's not going to necessarily disrupt your circadian rhythm, but it can certainly cause eyestrain stress and may be macular degeneration according to some the stuff that I read. Any concerns about excessive blue without matching red and infrared during the day?

Satchin: These days people don't get enough blue light that's the biggest concern because-

Dave: Or because they're not outside.

Satchin: ... they're not outside because we have now data from a couple of thousand people over a few years. Then what we're finding is most people get their daylight only when they're driving from home to work or work to home. That might not be enough particularly if you're wearing sunglasses when you're driving.

Dave: Okay. You're not going to get any then. But I mean you're getting some blue light and sunlight, but you're also at the same time getting the entire spectrum of light. But when you go into an office you're getting narrow spikes of blue light probably five times more than you'd get outdoors, but you're getting very little red and infrared and even the warmer spectrum. Any concerns about the mix, like fat, protein, carbs? Like what type of fat, protein, and carbs and what are the ratios? Do you think that that matters for light or maybe not circadian reasons?

Satchin: Well I think that matter. I think there will be more papers coming out this year or the next showing how other spectrum of light have better benefit for our health and wellbeing. One is that it is ideal that having a good ratio of red, green, and blue which is similar to what we get in daylight is good for our eyes.

Satchin: For example now people have shown, I mean it's a widespread phenomena that children are not exposed to daylight too much. They're mostly exposed to narrow spectrum of light indoor. Their eyes don't develop well so they have myopia and they need glasses very early on.

Satchin: The idea is maybe the rod and cone cells are not getting the right proportion of light, red, green, and blue. That's making the eye to bend slightly differently or the cornea to bend differently that leads to myopia. The bottom line is if we can get as close to daylight in our indoor lighting, that's much better. The best way to get to daylight is to have large window and bring some daylight in.

Dave: Yes, but then again the Salk Institute is in San Diego and you're right on the water and it's probably the most beautiful campus anywhere, but I'm in the Pacific Northwest. I can open the windows and all I see is gray schmutz. Should I be putting some lamps in?

Satchin: No. I think even that gray light you see have 1000 to 1500 lux of light coming through your window. Inside home and outside, you're still getting 10,000 lux of daylight. So that's good enough, but if you want to crank it up particularly when you go five feet away from the window, your light level is dropping. If you want to bring in some daylight, then maybe you can crank it up with some artificial daylight.

Dave: That's definitely what I do. I grew up in a desert and it just feels dark up here. So during the winter I feel much better. I've got a really bright halogen light here that makes a big difference. The other thing that I don't know if there were studies yet, but I've put a red LED light either somewhere in the ceiling or behind the monitor so that I'm changing the ratio. I figured if I'm going to get more blue light, I might as well get a little bit of red.

Dave: Ideally, like you said, we're going to know the perfect mix for us, but in the meantime, I just know that our ratios are way off with indoor lighting and monitor. So, I'll do what I

can to balance out the short wave light, like blue and the longer wave like red and it seems to make my brain work better but I don't have great science on that. Do you see anything about the idea of changing the mix or that's all coming in the next couple of years?

Satchin: I think there are a couple of studies showing the pre-paths to ... sorry, red light illumination followed by blue actually improves your brain function. That's a sequential illumination. So, it'll be interesting to see whether the mixer has better than the sequential illumination. That's was a human study with fMRI and everything. So it was a very solid study.

Dave: Oh, cool. Here's a hack for that that I've been doing for years. I have a light in my shower that's wired in a switch that's red. So when I'm showering, I've got a red flood light in the morning, and then I go out I'm going to get my blue light. Maybe I'm a super dog, I admit I am, but I think the stuff helps. Maybe it's just a little bit here and there, but I'm happy you mentioned that study because I don't know about that study.

Satchin: Yeah.

Dave: I want to ask about more of your work. I think that informs a Circadian Code, your book. You talk about a single gene that controls central timing system in the body and that pair genes that keep eating and sleeping in sync. Can you walk me through those genes and what they are?

Satchin: Yes. Well, at least now a dozen genes from the circadian rhythms. Actually, the name of one of the genes itself is CLOCK. This pairs up with another gene called BMAL. So there is CLOCK and BMAL. They turn on other sets of genes, which are also called Period, Cryptochrome, Rev-Erb and a few other genes. These genes turn on and it's almost like you can think of it's like an ice maker in your freezer. When the ice maker starts making ice, yes for the next few hours it will make ice until it reaches a level where touches the sensor and the ice maker so the ice making stops.

Satchin: Similarly, CLOCK and BMAL will drive these genes to some extent and then they'll stop because these protein levels will build up and will say tell CLOCK and BMAL that that's enough. Let's stop now and then the ice will melt or in this case this protein level will go down. So this thing happens in every 24 hours. There will be build up of this ice or these proteins and then for the next 12 hours they will go down. So that seems to work almost in every cell.

Satchin: Every brain cell, every skin cell, every stomach cell, every cell has the same circadian CLOCK. But what is interesting is to ... So then the question is, what is the function of circadian clock? What is it really doing? So what we think is clocks do a few things. One it anticipates events.

Satchin: For example, before we wake up, clocks in our brain and body work together to build up a day hormone, in this case cortisol, and warm up your body, make your heart beat slightly faster, breathing becomes faster so that when you wake up, you're actually full

of energy. So that's why having a good circadian clock and good night sleep makes you more alert and energetic when you wake up because your body can anticipate when you're going to wake up.

Satchin: Similarly, it anticipates when you're going to have breakfast. As soon as you have your breakfast, your gut microbiome, your gut enzymes and everything is working in sync to digest that food very well. So one anticipation. The second one is to separate incompatible process so that you don't feel hungry in the middle of the night because feeling hungry and sleeping are not compatible. You cannot eat while you're eating. That's a very bad combination.

Satchin: Similarly, our body cannot make fat and break fat at the same time. Our body cannot make cholesterol and break cholesterol at the same time. So having these things to be done at different times actually improves productivity of our body. In my book, in four to five chapters, I go over how the clock in gut works, how the clock in our liver and kidney they work with the same principles so that we're at peak performance.

Dave: Do you think that we're going to find more genes and if we do, are they going to be nuclear genes or mitochondrial genes?

Satchin: Well, this field circadian rhythm is really rapidly growing because we know that these genes are not acting alone. Almost every month, we're finding a new gene that collaborates with one of the central CLOCK genes. In that way, these CLOCK genes work with many different pathways.

Satchin: For example, the CLOCK genes also interact very closely with proteins that sense steroid hormones or cortisol, our body's natural steroid hormone. In that way, what CLOCK genes do is they dump out the effect of excess steroid at the right time and they can amplify the effect of steroid at another time. That's one interesting aspect of CLOCK gene regulation of steroid function that came out recently.

Satchin: Similarly, there are also new data showing that the CLOCK genes interact with inflammation pathway. That's very exciting because if you think of inflammation, inflammation is body's natural response to an infection or maybe from our gut whenever we get LPS leaking into our bloodstream, then our immune system has to respond to it. But at the same time, the inflammation should continue only for few hours, and then that will dump out because having continuous inflammation is bad.

Satchin: So this new interaction between CLOCK genes and inflammation pathway is showing that the CLOCK genes help inflammation to turn off after a few hours. When we don't have a functional clock, then inflammation continues linearly and over time, it can accumulate and lead to chronic inflammation. Similarly, we're seeing that CLOCK genes affect many different pathways. This is how we now connect CLOCK genes to cell division or tumor inflammation or cancer prevention.

Satchin: CLOCK genes to even neurochemicals or the neurotransmitters, how they signal inside the cells so that we can synthesis the blood cells to neurotransmitters only for certain

time of the day. Then switch up their sensitivity so that our brain can go back to sleep and sleep better at night. So this is an expanding area where we're begin to see, we're continuing to see right now there may be five different genes that directly interact with CLOCK genes, all the CLOCK gene products, and this number is going to grow in the next few years.

Dave: So people who've read the book, Bulletproof Diet or Head Strong or have listened to the show for a while, they know that inflammation from any cause is something that you got to get on top of if you want to perform really well now and die a lot later than you otherwise would. Inflammation and Trump's cholesterol and a lot of other things.

Satchin: Yeah.

Dave: So you found a novel pathway here and other researchers working in similar fields are finding that novel pathway, these CLOCK genes are affecting how long inflammation stays turned on, and this time restricted eating or intermittent fasting so do the two ideas go in alignment. But you're also saying, if you're doing intermittent fasting, you better stop eating before it gets dark, which is fantastic, right?

Satchin: Yeah.

Dave: Light exposure are also going to be variables that make a difference, but there's a problem and this is one of the sleep hacks and you'll see all over the Internet now. It originated when I wrote my book on fertility called The Better Baby Book. When women are pregnant, they're much more likely to wake up between 3:00 and 5:00 in the morning, and a lot of people who aren't pregnant, men and women, have this problem. They wake up and they can't go back to sleep and their mind racing and things like that.

Dave: What is happening in many of these cases is their blood sugar crash. They didn't have enough blood sugar to basically run the lymphatic system into sleep. So, the body said, "Oh I know how to make sugar. Well let's secrete some cortisol, maybe a little adrenaline because those raise blood sugar. Therefore, now I have enough fuel for the brain." Unfortunately cortisol and adrenaline wake you up a 3:00 to 5:00 and you can't go back to sleep.

Dave: So the hack for that was I found two different groups. Maybe it's the gene. I don't have the genetic testing to tell what it is, but one group of people they did some collagen protein, high in glycine and low in the stimulating amino acids that [inaudible 00:58:12] the same way modafinil does. Some of that out with some ketogenic things, did I say brain octane which raises ketones, they enough energy that they sleep through the night.

Dave: Then the other half of people, they take a teaspoon or two of raw honey. I found a study that it raised liver glycogen 22% more than [inaudible 00:58:31] or other forms of sugar and liver glycogen can feel the brain effectively versus muscle glycogen. I mean like try it out. If you're having this problem, a little bit of this before sleep can stop you from

waking up because of the blood sugar stabilizing effect of honey, not in hot tea because then it's cooked honey but raw honey.

Dave: Those are both eating before bed. They're small amounts. We're talking five, 10 grams. Is there some lower limit of food like that that's not going to break rhythm because I don't want to break my circadian rhythm, but I want to sleep all night? What do you do for that case?

Satchin: Well, we haven't done anything like that because it's a moving target. It's people who say how much is small enough. The reason why that raw honey or whatever you're eating is going to your liver and is getting stored is because the whole system wakes up. So we haven't done any research in that area, but what we have seen is people who do timed distributed eating, they do sleep very well. Maybe they normalize the way their body learns how much glycogen to store.

Satchin: This relates to a very interesting circadian rhythm study done in plants. You may laugh at it, but we learnt a lot of insights into circadian rhythm from plants. If you think about plants, plants have to make food only during day time when there's sunlight. At night, they don't have access to anything else. The only food source is their stored starch, and they have to break down that starch to go through the night. They cannot have this estrogenous food. They cannot just absorb glucose from the soil or anything else.

Satchin: What happens it the circadian clock in plants if you're growing plants say in 10 hours light, 14 hours darkness, then the plants will learn that they have to go through 14 hours of darkness. So they will store just enough starch that will last exactly 14 hours when they wake up.

Dave: Wow.

Satchin: Now you take the same plant, and make the night, 10 hours night and 14 hours of light. Even though they're getting more light, they're not going to store too much starch. Again, they'll dial down and they'll store exactly the same amount of starch they need to go over the 10 hours night. In fact, when this paper came out, it was from UK and it was few years ago when UK was having some problem with their budget. So the headline was a tiny plant knows how to manage its economy, but a British finance minster doesn't know it.

Dave: That sounds uniquely British like their press.

Satchin: Similarly, one has a very strong circadian rhythm while we go through a very regular habit of when we stop eating, then our body will learn how much stored glycogen the body needs. Maybe that is what is happening because we see that people who do time restricted eating, they always report that they sleep, but are particularly just waking up at three o'clock.

Satchin: I used to wake up at three o'clock for an hour or two. Then I thought that was normal because they are so common. But then quickly I realized that what is common is not

normal because you need that continuous restorative sleep. Now it feels much better waking up after continuous sleep than waking up in the middle of the night and staying awake for one or two hours.

Dave: I've always been a fan of sleeping all night and that's what I typically do. What I have noticed is that this is over eight years of the blog and talking with people before that and antiaging and all. The people who wake up at 3:00 in the morning typically are not the healthiest population.

Satchin: Yeah.

Dave: I mean, they're having cortisol regulation issues. They have a lot of stress or there can be some hormonal thing going on. That's why I'll say during pregnancy this can popup when it wasn't there before because you have hormonal swings. You have increased energy demands on the body. Or you get someone who just started an exercise program and all over a sudden I need more energy than I had before and I don't have it.

Dave: So I fully agree with you. You shouldn't need to do that, but if it's affecting your life right now as you're working on getting your circadian rhythm going, you might look at those as sleep hacks. But if you need to do it every single night, then maybe you should look at the temperature of your lights.

Satchin: Yeah.

Dave: All right. Well thanks for helping me walk through that sleep hack. I love seeing people say collagen before bed, raw honey before bed. I'm like great. That idea of hacking your sleep has gotten everywhere kind of put butter on your coffee thing. These are important things. All right.

Dave: Let's talk about astronauts. Okay. They seem like they're going to have the worst garbage circadian rhythm of any human center because it's always noisy in the spaceships and space stations. The lighting is junk light, [inaudible 01:03:43] definition. There is no sunlight and if there is, it is through heavily shielded lead filtered windows and things like that.

Dave: They're on weird sleep schedules and probably gravity affects circadian rhythm too that we haven't figured out yet. What are we going to do to fix the circadian rhythm of astronauts? Put on your science fiction hat and give yourself a $10 billion budget. What would you do?

Satchin: Well, the first thing is the circadian lighting. In fact, the International Space Station got new circadian lighting a couple of years ago. This lighting will simulate as close as possible to daylight for 10 to 12 hours and the switch to red light at night. We'll see whether that helps astronauts.

Satchin: They're going through so many different distractions. In every 90 minutes they're seeing a new sunrise and sunset. If I was in International Space Station and I know that my days

are numbered literally because you cannot stay there for more than six months or nine months, then you're curious. You always want to get up and then see what is going on down there, down on the earth. That's one problem, but I think long-term spaceflight is always a big problem, like how are we going to sustain that long-term spaceflight?

Satchin: This is where maybe time restricted eating will also help because we know that astronauts may get better sleep if they're on timed distributed eating combined with circadian lighting. Maybe we'll also see whether the astronauts can go through slight calorie restriction because calorie restriction or reducing calories even with time restricted eating will naturally boost their ketone bodies. That will help to keep their brain sharp because we don't want them to be dumb. We don't want them to be too tired.

Satchin: So finding that that sweet spot where they can, their body can generate enough ketone bodies to keep their brain working and during fasting, they can also lower their body, cold body temperature. That way, they may need less oxygen because oxygen is a big commodity is space station. It all depends on how much oxygen ... It's very simple math. How much oxygen, how much water you can carry with you. If you can reduce, slow down metabolism because they're not running 20,000 steps coming back to your pedometers. They're not expected to do heavy weightlifting although that's necessary to maintain their muscle mass.

Satchin: This will be a long-term story to figure out how to reduce or maintain metabolism with the modest trends that will reduce the amount on oxygen, reduce the amount on water, reduce the amount on how much recycling they have to do, at the same time stay at peak performance. I don't see that the lifestyle that we have on earth eat whenever we want and eat too much food, get exposed to junk lighting all of these things will help them.

Satchin: So I think that might be the case. That might be the exact ideal situation where we can figure out the optimal circadian code to keep astronauts fully active and fully productive for very long time without compromising their health span lifespan. If we can figure that out just like many technologies that we use started from the International Space Station, maybe the optimal circadian code for astronauts will trickle down literally to the earth and they can figure out the best way to live.

Dave: I'm hopeful that it's a two-way street. We'll have more effective astronauts who can go to other planets and do cool stuff, but if we don't hack this, we have an issue.

Satchin: Yeah.

Dave: You mentioned something important about caloric restriction. There are studies now that show eating too many calories makes you age faster. There are studies that show eating too much animal protein or other amino acids that are found in animal protein that are also found in vegetable protein things like to some extent glutamine, methionine, trophamine, and cysteine that these affect [inaudible 01:08:21]. They make

you age more quickly and they're not for you in excess even though they're required in small amounts.

Dave: We know that eating too much of anything is bad. Eating too much proteins is bad. Eating too many carbs is bad and probably eating too much or certainly the wrong kinds of fat is bad and eating too much fat that's high calorie so you got too many calories. That's also bad. I've written in a couple of my books about longer fasting than time restricted eating or intermittent fasting. I've talked about 24- and 48-hour fasts. I regularly do a 24- to 48-hour fast probably at least once a month or sometimes more often.

Dave: What is your take on longer fasts? Maybe even going to up to three or four days where you're just having water ... I'll do water and black coffee because come on, but during that time what is that going to do into my circadian rhythm? Is it advisable? How does that line up with the circadian code?

Satchin: Well, the circadian rhythms well continues with longer fast. It actually goes through a longer rejuvenation maybe. We haven't looked at longer fasting animals because animals don't like this very long fast. They only fast for two to three days. In humans, we know there are a lot of studies from other groups showing that longer fast are very good in reversing or managing many chronic disease.

Satchin: We know that longer fast will activate [inaudible 01:09:54] to much higher level, so that will help. Longer fast might also increase your ketone body production. That also helps. So all the indications are yes longer fast, if you can do, are beneficial for the body. It's not going to disturb the circadian clock because the circadian is an internal time keeping mechanism that continues even without calorie and that's how it will anticipate when you should go to bed, when you should wake up.

Satchin: In fact, people who do longer fast, they always report that it's not that they cannot go to be because they're hungry. They actually go to bed much better and they stay. They have their good night sleep even during longer fast.

Dave: Yeah. I sleep well during longer fasts.

Satchin: Yeah.

Dave: One question for you. When you exit a longer fast, we know that you're more insulin sensitive in the morning. In fact, if you were to do intermittent fasting and probably time restricted eating, if you are to do it ideally you'd probably have a giant breakfast and skip dinner. It's just no one will do that. None of my coaching clients ever want to do it. I don't want to do it because dinner is a big part of our social life and you have to be lone wolf programmer to pull off that lifestyle. So you've finished a 48-hour fast. Do you finish it with breakfast or finish it with dinner?

Satchin: Well, when you finish the 48-hour or 72 or multi-day fast, breaking the fast is not easy because your body has forgotten food. You don't have that appetite for a big meal. Usually, you break it with a small meal. So in that way-

Dave: Like a one pound rib eye steak the way I do it or? Just kidding. [crosstalk 01:11:46].

Satchin: I wonder how you make it, but for me, the first time I break is usually a small salad or a fruit or something like that. So I'm not hungry but I do-

Dave: Yeah, it's surprising. Yeah. You're not hungry at all.

Satchin: When I do long fast, it's usually four or five days minimum. By the end of four or five days, you have to force yourself to eat. So I usually break the fast in the afternoon because that's when I have time to break the fast because it takes, even for that small salad, I take relatively long time to even force that. So I think it will be very personal what time they are planning to break the fast and whether they're planning to break the fast alone or with somebody else. But then the idea is don't break the fast with a big meal.

Dave: I agree with that by the way. I was joking about the rib eye.

Satchin: I figured out.

Dave: All right. Cool. Well is there anything else that you would like hundreds of thousands of listeners to know about their circadian biology, about your work? You've done so much, but you've got a big microphone right now. Help people with some stuff you know.

Satchin: Well, the thing is the last couple of years a few things that have come out that are very reassuring and essentially telling that timing makes healthy food junk. The bottom line is this. Last year there was a study that came out from Joe Takahashi lab who is considered a leader in this circadian rhythm field because he discovered the gene CLOCK.

Satchin: What he found was we know that caloric restriction is beneficial, but most caloric restriction studies in mice and larger animals are done in a way that the mice are given their chunk of food which is less than what they should be eating. This chunk of food is given usually in the afternoon or evening.

Dave: Yes.

Satchin: And mice eat that food within three to four hours every single day. Essentially all caloric restriction studies done in rodents are a mixture of caloric restriction and time restriction because they're going through almost 20 hours of fast.

Dave: Well also aren't those nocturnal animals who should be eating at night and yet have weird indoor lighting disturbing things as well?

Satchin: Well, that's why the second part of Joe's experiment is exciting.

Dave: Oh, okay.

Satchin: He took two groups of mice and did caloric restriction on both of them. One group got food in the evening when they're supposed to get. Then the other group got food in the morning, and both groups got the exact same number of calories from caloric restriction. If we go by CRL, caloric restriction literature, both groups would see the same benefit irrespective of timing.

Satchin: What was exciting was the morning fed mice did not lose weight although they were less food. That was really interesting that even if you are doing caloric restriction, if you eat at the wrong time, then you may not see sufficient benefit of caloric restriction.

Dave: I mean, here's the deal. If some joker tells you that calories in and calories out, losing weight is just a matter of counting calories, you can just quote that. You can cut out the snippet. You can send it to them. Here's the deal. That science is dead. There's a nail in it.

Satchin: Yeah.

Dave: If that's not enough, let's just give a little bit of xenoestrogen to some of the mice in caloric research and then see whether they lose weight. They won't. So screw calories. Yes, calories matters. You do not lose weight by cutting calories. You have to cut the right calories at the right time and do the other stuff.

Satchin: Yeah.

Dave: Thank you for pointing that one out. Also, have using the studies on the difference in mouse outcomes based on whether a man feeds the mouse versus a woman?

Satchin: Oh yeah. That's mostly mouse behavior studies. When female students are technicians, the grad students they handle the mice, then the outcome from behavior studies they're much better than the males. Somehow the mice don't like males.

Satchin: There's another one from ketogenic diet in mouse. People would think that ketogenic diet will increase lifespan. So there are two studies done that came out last year and in both studies, mice were given ketogenic diet at ad libitum, whenever they can eat. In another study, in one study actually the ketogenic diet was given once a day. So that means they were self-imposing time restricted eating.

Satchin: Only when ketogenic diet was given once a day and they were eating all this food within 10 to 12 hours, those mice only saw some benefit of ketogenic diet. These mice lived slightly longer and they had better health outcomes. But when the ketogenic diet was given ad libitum, so mice can eat whenever they want, those mice actually had worse health outcomes compared to even mice that are eating normal diet, standard diet.

Dave: Wow.

Satchin: So this is again another case where ketogenic diet, which seems to have a lot of benefit has to be combined with time restriction.

Dave: Yeah, you've got to do it right. Also, mouse studies when they feed them, they sell this ridiculous idea that fat is fat and protein is protein. They say, "Look, we've fed them fat." Look, if you feed a mouse corn oil, it's going to be different than if you feed them butter. They do different things in the liver. They do different things in the body. A lot of the mouse feeding studies they boil it down, it's like saying, "We gave them this amount of liquid." Well, if they were drinking kerosene, you're going to have a different outcome than if it was water, but since it was all liquid, we just boiled it down to liquid.

Dave: I'm a little frustrated in some of these studies because we know that the feeding casing, which is a cancer promoting in excess for sure especially with aflatoxin that's common in [inaudible 01:18:00]. If you do that, you're just going to screw up the study. How much faith do you put in mouse and rat studies for circadian biology in vivo not in vitro? I mean [crosstalk 01:18:12]-

Satchin: Yeah. In vivo studies, if we think about say mouse and rat study versus human studies, human studies are worse because we don't have control over genetics, [inaudible 01:18:25] ties. Then we cannot people inside indoor and then feed them at the right time.

Dave: I thought that was what school was for.

Satchin: Yeah. So every study has its own strengths and limitations. The nice thing about the mouse and rat study whatever we do is we can be completely transparent about which particular diet source we used. We can even put the catalog numbers so we know these mice had that particular diet from this supplier. Then supplier has all the ingredients, whether it was artificial, natural and [inaudible 01:18:57] source. In that way, we know in very detail what kind of food these mice ate every single day.

Satchin: Just like you said, in retrospect, for example if we figure out that this particular food component can cause cancer or can cause some side effects, we can always go back to the study and then check whether that's what's causing some problems. So that's the nice thing about the laboratory study is everything is transparent and everything we know what happened the mice and what is the experiment was done, even from which source the mouse came.

Satchin: For example, now with the gut microbiome we know that if we get mice from one supplier versus the other supplier, these mice were born in different case so they might have different gut microbiome. That can affect our outcome.

Dave: Oh yeah, that's right.

Satchin: In fact, that has been shown now that when mice are procured from one vendor, then they fare very badly with their diet, whereas the other vendor mice fared very well. Then people went back and nailed it to the microbiome in the original case from where

the mice were born. So those are the kind of stuff that we cannot do in human because we cannot keep track about the light history.

Satchin: I agree that a lot of the mouse experiments may not translate to human but at least we have more transparency and more knowledge, more information about the mice, their genotype, their microbiome, their diet, the light dark cycle. For example, all mice and all vivariums go through 12 hours of light and 12 hours of darkness. That's standard. We don't even have that for any human studies because every human is very different. They'll have different sleep pattern, different light exposure.

Satchin: So that's the beauty of mouse experiment. That's also the weakness because we can always go back and say, "Well you did this wrong or you did only in young mice and you cannot translate to older mice." Many of the mouse experiments in metabolism are done only on male mice, not on female mice. But at least we know that those are done only on male mice.

Dave: Got it. I think there's great data and knowledge in them, but if you take one study, I'm pretty sure they didn't account for the cycle of the moon and all these other things that none one thought might matter but it might.

Satchin: Yeah.

Dave: Beautiful. Satchin Panda, your work is truly groundbreaking on a circadian biology. I will never forget standing there in your lab and looking at retinal cells from a mouse on a high-powered microscope and okay, do you see those melanopsin cells studied with mitochondria? That really helped to shape some of my thinking for Head Strong. I'm grateful you took me in that tour of your lab.

Dave: I'm grateful that you've come on the show and that you wrote the Circadian Code. Really, I've just pointed out this idea that it's not just your intermittent fasting for keto bros, but that it's when you're doing it. There's time restricted eating that you've talked about it in the context of your mom.

Satchin: Yeah.

Dave: She got healthier. She's not doing Kettlebells.

Satchin: No.

Dave: She's not doing anything crazy-

Satchin: Yes.

Dave: ... but her Type II diabetes went away because she followed stuff in the Circadian Code. I think you're changing a lot of lives with your work. I'm glad you're doing it.

Satchin: Thank you so much, Dave. I'm always happy to be on your show.

Dave: I've got a final question for you-

Satchin: Yeah.

Dave: ... because I've been really public. I was just in Men's Health where I'm doing everything in my power to live to at least 180. I figure I have seen people do 120, so I know it's possible. I figure I have a pretty unfair advantage because well I can start now and I got a lot of knowledge and et cetera, et cetera, so maybe I can do that.

Dave: I'm guessing that over the next 75 or so years we're going to have a few advances in human life extension based on the technology stuff you're working on, stuff that many friends are working on. I get to see behind the scenes on the antiaging movement. So, I'm counting on some tech to help me there. That's my number. What's yours? How long are you going to live?

Satchin: How long I'm going to live. Actually, I don't want to live too long because I'll lose many of my friends and [crosstalk 01:23:23]-

Dave: So even if you felt like you do now, you have your energy, your body, your mind, you're not in walker. You know your name. You don't put your keys in the refrigerator. All those things, still not too long?

Satchin: Yeah. I really don't want to put a number there because one thing is we still know that our genetics play a big role in longevity. That's something that we don't know. In my lifetime, I don't think we can change by crisp or any other technology hundreds of thousands of genes to change my lifespan. So there is one thing that I stay away from is to predict how long I'm going to live. But one thing I'm sure is-

Dave: I respect that. I respect that. That's okay, but what's the one thing.

Satchin: One thing that I'm sure is I will be active in science for the next 6,956 days.

Dave: Why that number?

Satchin: No. That's the day when I'm planning to retire from current job-

Dave: Here you go.

Satchin: ... and it's on my whiteboard right here.

Dave: Wow. Okay. Bonus question then-

Satchin: So after I do that, then I'll decide in my next thing that I do after quitting science, so quitting my current office or job, how happy I am and how long I want to live.

Dave: That is an epic answer and it makes so much sense. Thank you for being on the show. Thank you for your work. If you like Satchin Panda's knowledge, you got to read the

Circadian Code. Also, you should get myCircadianClock and Satchin, what's the name of the other app you mentioned, the lux app?

Satchin: myLuxRecorder.

Dave: myLuxRecorder. So if you're a bio-hacker right there, I'm actually downloading that right now. It's called myLuxRecorder.

Satchin: So the only glitch is it doesn't work with iPhone 6 or 6S with iOS 12. Somehow we go to hack that, but then the nice thing is wherever I go almost in every airport, every grocery store I've been recording light. It just gets you a perspective about how much light we have around us in the evening.

Dave: I have a $10,000 light sensor that's part of the TrueDark company's research and all, but it's too much of a pain to walk around with it and all so I never do. It's at their headquarters and all. So having it on my phone, you just made my day. Satchin, thanks again, man.

Satchin: Thank you.