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 anxiety may be inherited from your parents' brain activity patterns. And researchers found a pattern of this brain activity that's tied to anxiety, and traced it through generations of monkeys. There's also this large study of about 400 monkeys bringing us a little closer to understanding severe anxiety, and how it's inheritable. This came from the University of Wisconsin School of Medicine, and they say this new activity pattern really acts almost like genes going through your family tree.

Dave: They measured anxious temperament by subjecting young monkeys to a stressful situation. And they measured how they responded to that situation, or how strong of a response they had, and they measured their levels of cortisol, and they figured out which monkeys stress harder than other monkeys. And then they scanned the monkeys brains under anesthesia, and the monkeys that had the bigger stress response showed a crucial difference in the extended amygdala, which is a brain structure and its surrounding that's known to be involved in fear and threat detection. Oh, and if you meditate, it's probably involved in some of the more esoteric spiritual states you can achieve when you train it the other way, but no one ever talks about that. That wasn't in the study either.

Dave: But two parts in particular, of the amygdala. The central nucleus, and the bed nucleus of the stria terminalis behaved in lockstep in the high stress monkeys. And this is through functional MRI scans. And they found if your parents had it, the kids had it along with that anxious temperament. What this means is that you can blame your mom for your mitochondria, but you can blame both of your parents for your anxiety. Either that or maybe you should just do some basic forgiveness and all that stuff, and be done with that crap, because you can retrain your amygdala. They didn't put that in the study either, but that's been a big part of my path to being not an anxious jerk.

Dave: All right. Now, I typically like to foreshadow, and you can wonder am I going to be talking about monkeys, FMRIs, or anxiety? In this case, well none of the above, and maybe a little bit of the above because we are talking about neuroscience, and we're talking with a leading Bay Area based PhD, who studies comparative neurology to understand our brains and brain evolution, and he's doing this at Stanford School of Medicine where he's a professor of neurobiology, and he's made a bunch of important contributions to the field of brain development, brain plasticity, neural regeneration and repair, so of course that's why I want to talk to him. We're talking about none other than Dr. Andrew Huberman. Andrew, welcome to the show.

Andrew: Thanks so much for having me. I'm thrilled to be here.

Dave: Now, if you are a fan of neuroscience, which is pretty likely if you've been listening to the show for a while, we're going to define all of our terms as we go through the interview if you didn't know what the amygdala was, that's okay. Now, Andrew. You know of so much cool stuff, I almost didn't know where to start, when I'm thinking ... I wanted to ask you, because you talk about increasing cognitive capacity. Which is really cool, and you've done some really crazy martial arts and scuba diving. You're a very fit

neuroscientist, as opposed to the thick glasses, white lab coat, and overhanging belly that's probably the stereotypical neuroscience guy. So, let's start there. What's up with increasing cognitive capacity by leveraging your stress and arousal system? What does that even mean?

Andrew: Yeah. So, I've long been interested in perception, cognition, all of neuroscience, and the short history of this is the following. So, really there are five components to how you go through life. And only five. And they are the things you sense, right? The things you perceive, so which of those sensations you're focused on-

Dave: So, you could sense something, but you wouldn't consciously know you sensed it, you're saying?

Andrew: That's right. So, I could say right now you're sensing the bottoms of your feet in contact with the floor, but until you think about it, you weren't paying attention to it. You weren't perceiving it.

Dave: Correct.

Andrew: But you're sensing things all the time. You can't turn off the sensory epithelium as we call it, the sensory sheet of your eyes and your ears, and your nose, and your mouth. And the rest. You're basically, you're sensing things all the time.

Dave: You can turn those off with either lidocaine or LSD, right?

Andrew: Yeah, those are pretty extreme circumstances.

Dave: Okay, but I'm saying but when you do those, weird stuff happens. Like anytime you walked around going, "I can't feel my hands", or, "I can't feel my face after I do ..." Those are extreme states that everyone remembers, because they're so bizarre.

Andrew: Yeah, I mean you could amputate a limb too, but-

Dave: That's a good point.

Andrew: Yeah, so I guess I'm referring to sort of basal states-

Dave: Okay, the normal states, okay.

Andrew: I don't mean to be nitpicky, but that's ... yeah. So, you know, you're sensing things all the time. And then there's what you perceive, which is what you're focused on, and then there are your emotions slash feelings, and I'd like to call them emotions, not feelings, because when you call them feelings, they're sometimes confused with sensations, as the feel part. That's just a semantic thing. And then there are your thoughts, which are interesting and we can talk about that a little bit more. And then there are your actions. So, that's it. You've got sensations, perceptions, emotions,

thoughts, and actions. And that's essentially all your experience. And of course, you're engaged in those simultaneously to varying degrees at any time.

Andrew: And then there's this thing that they all ride on, which is your level of alertness, or let's call it autonomic arousal. Some people like to call it stress, but that gets a little tricky. Let's just call it autonomic arousal. Here's what I mean by that. When you're dead, you're not going to experience any of those things, as far as I know.

Dave: Right.

Andrew: Never been dead, so I don't know. Now, as your alertness ... let's say you're fast asleep. You're sensing things, you're having thoughts. They're not very organized most of the time. You can even have feelings. You can have emotions within sleep, we know that. And you have very limited behaviors unless you're a sleepwalker or something like that. But as you become alert and calm, more of those things become available to you, like deliberate conscious thought, and as you [inaudible 00:06:32] feelings about your morning, the people in your life, your life plans, your past, et cetera, as you become more and more ... some people like to call it stress, but as autonomic arousal goes up, the weights of those things and what's available to you, shifts dramatically.

Andrew: So, your ability to engage in conscious deliberate thought goes down as autonomic arousal reaches peak levels. So, if you're in a panic it's very hard to think about things in an organized way.

Dave: This is like the stuff that Lieutenant Colonial Grossman, who wrote *On Combat* was just on the show, and he talks about at the very extreme states, how even soldiers, they just go to training because they can't think, they can't do any of that stuff. And you're saying even as you approach that, your cognitive ability goes down as your stress levels go up.

Andrew: That is right. And if I look at the whole of wellness, or biohacking, there are tools that are designed to control autonomic arousal that fall into different categories. Like the ones that are designed to raise your ceiling on what you perceive as stress. Ice baths, hard runs, these kinds of things. There's a whole galaxy of those, as you know. And then there are the ones that are designed to bring your stress level down once you enter the stress response, to kind of tamp it down consciously. And then there are the ones that are sort of designed to bring your state up. Wim Hof breathing comes to mind. Oxygen dominated breathing. We can get into this in more detail if you like.

Andrew: But in any case, in thinking about brain activity and life experience in this way, I became interested in the following question. So, I'm classically a visual neuroscientist, meaning that my lab studies visual perception and the nerve cells, and connections in the brain that mediate visual perception, because we're just such visually driven animals. About 40% of the human brain is devoted to visual processing in some way. As well as merged with other sensory modalities, like hearing. But I was interested in why some visual stimuli create anxiety, or increased autonomic arousal, and some perhaps, and we can get into this, actually decrease autonomic arousal and potentially could be used as stress management tools that are very fast and in real time.

Dave: Do you mean, when you say visual stimuli, do you mean like flashing lights? Or pictures of zombies or something? What are we talking about here?

Andrew: Yeah, great. So, if you see a picture of something that frightens you, even if you don't have a phobia, your autonomic arousal immediately spikes. We're all familiar with that. There are things like light exposure, overall light exposure, with no form whatsoever, what's called ambient light. Like the overall level ambient light delivered early in the day will increase your autonomic arousal. It will actually increase alertness. There's a very powerful circuit for this, and you know well about this, and that's the circuit that you want to avoid triggering late in the evening, which is why you might wear blue blockers or something too. Or not ... avoid looking at your phone in the wee hours.

Dave: Right.

Andrew: So, light and visual stimuli have a powerful control over autonomic arousal, and the nice thing is, in a scientific sense about vision is you can completely control what are called the statistics of a visual scene. So, whereas showing somebody a zombie is kind of a complicated visual stimulus, in some ways it's actually very simple. I know exactly where the lines are in that image, I can make them different contrasts, I can make them different speeds, I can give them more or less reality depending on how I contour them. All of this is to say that a few years ago, I decided to start addressing stress, the question of what is stress in the brain, what are the circuits, what is the potential for the visual system to be used as an intervention for stress management, both preventing going into the stress response as well as managing the stress response once you're in it.

Andrew: And that brought us to an interesting question, which is the one that you asked, which is how is it that autonomic arousal, which I can modulate using the visual system, and I can get into that in more detail if you like, how is it that autonomic arousal allows someone to process more information or less information? Is there a sweet spot in which being alert and maybe even slightly more in the stressed regime, actually allows me to process information better and faster? And here's the experiment that we did, that led to that hypothesis essentially. A student in the lab, Ph.D. student, was looking at the fear response in mice, just letting mice run around in this little empty aquarium, no water, and then showing an expanding black disk above them. And that essentially mimics their experience of an incoming predator.

Andrew: And so, mice will do one of two things, and they'll do it the first time and they'll do it every time, and they don't need to learn it. They'll freeze, or they'll run for shelter. Okay? So, mice are innately just naturally afraid. They'll freeze or run for shelter. Now, she mapped the circuits in the brain that mediate that response, and then she started increasing or decreasing the activity of these brain areas. She found an area of the thalamus, which is just kind of this egg shaped thing in the middle of the brain, called the nucleus reunions. This is a very poorly understood area of the brain, but it connects to the frontal cortex, and here's what was interesting. If she increased the activity of this brain area, that connects the thalamus to the frontal cortex, and she showed the animal a fear-inducing stimulus, the animal would confront the stimulus. It would no longer freeze or hide, it would literally walk out to the stimulus and rattle its tail, which is the mouse equivalent of beating its chest and saying, "Okay, let's go. Let's fight."

Dave: And what was-

Andrew: When she took off that structure, the animals became more fearful.

Dave: And how is she turning that on?

Andrew: She was using one of two techniques. One is called chemico-genetic, where she actually puts a virus that on its own doesn't really do anything bad, but with ... that carries a receptor, it's a muscarinic receptor that she can inject a drug to either silence or increase the activity of the structure. This is going to be the future of gene therapy in humans, things like this. Not that exactly, but right now you only do that in mice. But I'll talk about the work we're now doing in humans, that's-

Dave: That's so incredible. So, just tuning that part of the brain. I recently did transcranial magnetic stimulation of individual brain structures. You could probably hit the thalamus with that. In fact, I even have some gear here that does it with magnets at a lower amplitude than the quarter million dollar gear that they're using at the psychiatrist's office.

Andrew: Yeah, it's coming. You know, manipulations of brain circuitry are coming. And so, yeah. This is a circuit that literally changed fear into courage, and so we asked what's going on here? And so, it turns out that this circuit allows the animal to bypass the amygdala activation, I know you mentioned amygdala in your intro, to bypass amygdala activation, and instead to engage the frontal cortex. Now, that was all fine and good, and we were excited that we discovered that circuit. But the really interesting part was when she explored the level of stress in the animal when it was engaging in these so-called courageous or confrontational responses. The autonomic arousal measured at the level of heart rate and breathing was actually increased.

Andrew: So, we think of courage as this kind of calm state that allows you to engage in challenge without experiencing fear and negative emotion, but it's quite the contrary. And we know this because if someone were attacking you, your level of autonomic arousal or stress would go through the roof. But if I just got a snapshot of your response to that, you're going to fight back. Right? Whereas if they're just following you, you might hide, or get into your car and leave. So, the fear response is actually the lower arousal response. And that was all fine and good, and interesting, but then the third thing that she discovered was really what blew our minds, which was that when we did an experiment to ask the animals, and of course mice can't answer, you can ask them all you want but they won't answer. With did an experiment where she stimulated this brain area, when the animals were on one side of this little chamber or the other, this container, we found that they preferred the stimulation side. They love stimulation as pathway.

Andrew: So, this confrontational or courage pathway is actually directly linked, we discovered, to the dopamine reward pathway, and it means that successful confrontation of fear, meaning not dying, not getting eaten, not doing something stupid, but successful confrontation of fear, involves increases in your stress and is heavily rewarded in the

brain. So much so, circuitry is forever changed after that. So, this was a paper that we published in Nature, in 2018, in it immediately prompted us to say, "Okay, we have to do this in humans."

Dave: We do, do it in humans. Maybe not that exact study, but one of the things, Tony Robbins walking on coals, right? You feel like you're going to die, and then you stop and like, "Oh, I did it." And it changes our brains. Or you look at the flow genome stuff where one of the ways to go into a flow state is well, just almost die on a mountain bike doing 50 miles an hour, or skis or something, and you get that dopamine hit and you go into this altered state. It seems like we know that there's a reward system because we can see it in certain behavior patterns like that, but are you actually able to measure that in humans now?

Andrew: Yeah, so we immediately built up a virtual reality laboratory that looked exactly like the mouse laboratory, except bigger, of course. And this prompted us to go collect the most realistic fear-inducing or arousal producing stimuli that we could for VR, so that was what led to my collaboration with shark diver photographer Michael Muller, and doing cage exit shark diving and recording great whites to bring back that footage to the lab, and build VR experiences that are very realistic compared to most studies of fear. The history of studying neuroscience fear in humans is, in my opinion, has been a little deprived, let's say. But VR changes that because you can control everything within the VR, you can look at where people are looking, you can measure where their eyes are, you can get subjective reports, you can measure their breathing, their heart rate.

Andrew: But the real twist in all this that made it exciting was we teamed up with a neurosurgeon at UCSF, a guy named Eddie Chang, spectacular neurosurgeon, to actually record neurons from the human brain, both the amygdala, the visual cortex, structures like the insula, to actually get measurements of what the brain is doing in humans while people are going through these fear confrontation, courage versus freezing, types of scenarios. And what its taught us, and it's still early days for the human work, I should mention. That work isn't published yet, but what it's teaching us is that the capacity to maintain cognitive load, to perform a cognitive task, under conditions of high stress and arousal, are it actually ... you can train this up. You can essentially access and produce more cognitive information. You can basically think better. Let's just put it in plain language.

Andrew: You can think better, and do better in a complex game or in a simple game when your autonomic arousal is higher. And so, I'm very interested in this because I know there are a lot of people walking around that are really stressed, and people who are traumatized, and that's terrible, and certainly everyone should deal with that through the appropriate channels. But there is this real question, that what was autonomic arousal designed to do? Well, autonomic arousal was designed to leverage your behavior. It was designed ... once you got hungry enough, you were supposed to get agitated enough that you went and sought food.

Dave: When you say autonomic arousal, you're talking about sympathetic, like the fight or flight response being turned on enough. Not the sympathetic branch, or sorry, not the parasympathetic branch, the rest and reset branch of the autonomic system, right? You're talking about being a little stressed, enough to do a good work.

Andrew: That's right. I'm talking about why, and here's my theory. I'll try and weave this with some of the more common daily practices of people who don't have electrodes in their heads. You know, I've always found that a little bit of, for me, just for myself, a little bit of mild hunger, or the intermittent fasting thing, or the kind of ketogenic oriented nutrition always sharpened my focus. Back in 2000, or 2005, when I was a post doc at Stanford, I got teased a lot because I would drink the oil off the almond butter, and everyone was like, "Oh, gross." I could work very long hours that way. I always liked when I was working long hours to maintain a little bit of sympathetic tone, as they say. Be a little more on the stress regime.

Andrew: And when it was time to relax, you can eat some starches and crash out. And so, the nervous system is highly susceptible to these kinds of manipulations because, you have to remember that of course, and you know this, that autonomic arousal, even the stress that people feel around loneliness, that was installed in you to get you to go find a mate.

Dave: Oh, totally.

Andrew: Right? And if you are not lonely, like you have a mate, and you've mated recently, then there's a period of time, it varies between individuals, where you're content to be relaxed. It's parasympathetic dominance. Because nature ... So, you're being manipulated from the inside based on what nature wanted you to do, but you can leverage that. That's the power of that fourth element which is conscious thought. And so, it occurs to me that there are two states that most people want to be in. Not 50. There are psychedelic states, and there are other kinds of states, flow states, but the two states I think most people seek are alert and calm, and or asleep. And I feel like one of the beautiful and exciting that's happening with this biohacking movement, and with the wellness movement, is to find healthy sustainable ways to be alert and calm when you want, and asleep when you want.

Andrew: And if you're not good at it, to get better at it. And so, while lab doesn't work on those things directly, I'm just fascinated by the extent to which autonomic arousal can be used as a tool to get you where you want to go.

Dave: It makes so much sense. It's funny, because one of the things that I was kind of embarrassed to put in, in game changers, and there are four laws for high performance around sex. And relationships. Because it's one of those big three things that every cell in your body is wired to do, right? Even single celled organisms, if they don't have sex, or they don't reproduce in some way, the species will end, right? So, we're kind of wired. But I found that there really is an orgasm hangover, at least for men. And it has to do exactly with that arousal system. There's a couple days where you'll just relax, but if you wanted to get stuff done, you actually don't get stuff done the next day. You're a little bit more chill, and maybe a little bit less satisfied with life because you're like, "Meh, I got nothing to do today," sort of thing.

Dave: So, I published a year's worth of data, just on that which that was the embarrassing part. But what you're talking about there is the neuroscience behind that. So, you're saying if you don't eat, for a little while, not for a long period of time, you might perform better. Intermittent fasting, boom. There you go. I would say if you don't eat and you have

some extra ketones from say Bulletproof Coffee in the morning floating around, you're probably going to get even more of that, right? But if you go on ... the number one thing though, that we're all wired to do is run away from a killer, or hide from scary things. And you're saying having enough of that even is cognitive enhancing, but all right, I'm sitting here, completely vibing with what you're saying. How exactly am I going to get more of that first? The first F word, the fear F word, as opposed to the food F word? How am I going to get more of that without being at risk of braking limbs and getting TBIs and things like that?

Andrew: Yeah, I mean I think one of the things that the flow genome guys have really spelled out well, I went and saw one of their things recently, is this idea that you want to ... they have this list of kind of suggestions. They don't call them commandments, but one of their suggestions, and I don't work for them, they just ... I'm friendly with those guys-

Dave: Yeah, I was the first investor in the flow genome project, so I've [crosstalk 00:22:27].

Andrew: Oh nice. Yeah. I'm excited about what they're doing, because they're putting things into a really nice framework, which is you definitely don't want to end up in a body bag or in jail, or do something-

Dave: Its always been a concern about just do high speed skiing, and-

Andrew: Yeah, not for most people.

Dave: Yeah.

Andrew: And you can die, and people do die, and I worry that the threshold for that, especially with YouTube videos, and all that, and I watched and enjoyed Free Solo, but that's not something that most people should do, right?

Dave: Yeah.

Andrew: So, you have to make a very thorough assessment. So, the threshold is different for everybody, but what I would like people to appreciate, and I think certainly you do is that some level of an understanding about what the stress response is really for, reframes it from a pathology that we're supposed to run from and control at all costs, to something that you can think about developing tools for. So, I think of tools in terms of real time tools and offline tools. So, if the work that we're doing now, we look at both so-called normal subjects, and subjects who have generalized anxiety, and again it's early days, but what we're finding is that one way to measure or evaluate, as well as potentially control the stress response in real time, is by altering the way in which literally you look at the world.

Andrew: Now, here's why. So, the visual system has a powerful control over your level of autonomic arousal. So, you have to think about which direction you want to go. So, let's say I'm alert and kind of sleepy, and I'm not motivated or engaged. There are times when I'm not stressed, I'm kind of under stressed, and I need to lean into work or do

something. Yet there are a number of ways to do that. Of course many ... your listeners know them, and you have many of them. They're powerful. But we have two kinds of vision. One is panoramic vision, so-called magnocellular vision, because it's carried by big neurons that transmit information very fast, and it's designed to view the world in kind of panorama.

Andrew: So, if you dial out your gaze as you're listening to this, and just kind of see yourself, but see yourself in the entire room, or even better, if you're outdoors and you just see everything, the world kind of takes on a spherical shape. That's associated with a branch of the visual system. You're engaging a branch of the visual system that is more sort of parasympathetic dominant. It actually is, in animals that are grazing animals only have that system. They don't have what's called foveal vision. They don't have high acuity vision. They're grazing, and their only concern is to get their food while detecting if anything comes into their environment. It's actually a system that allows you to process information much faster, because the neurons are big, for potential threat detection. But it's a low anxiety state.

Andrew: Now, there are many yoga practices that are kind of associated with soft gaze, and things. But this is the neuroscience of that. And you can do it by dialing out your gaze. By contrast, when you focus your eyes on a single, what's called vergence point, and you enter foveal vision, you're now switching to high acuity vision, and your perception of time switches. This is what's key. You're altering the ... you start micro slicing time. So, big picture, time bends are bigger, small picture, time bends are smaller. Just simply by virtue of the two parallel circuits that we have in our brains. Primates have in their brains. Lions have in their brains. But animals like sheep and cows don't. They only have that panoramic vision.

Andrew: So, we've been exploring the lab the extent to which you can use your states of viewing the world as rapid ways to enter and adjust your level of autonomic arousal. So, when I'm kind of sleepy and I need to focus and do work, I actually focus on a cross hatch about a meter away, and for about a minute, and it actually acts to lock my attention, so you can actually ... there's a blip, a kind of increase in autonomic arousal goes up with that. And then I personally find it easier than to focus on a work task. Conversely, if I'm sort of in a stress state, people always say control your breathing. I'm a big fan of breath work as a way to control your breathing, but the problem is it's closed loop. So, if I'm really stressed, and I can't control my breathing, then controlling my breathing isn't an option. But dialing out your ... it's also not covert all the time. You can't do it in every circumstance. Can't do it if you're scuba diving, you can't do it under a number ...

Andrew: Sometimes you should, but adjusting breathing when in real time is a complicated thing because you don't want to compromise your activity. But you can dial out your gaze and very rapidly adjust down your level of autonomic arousal. In fact, the visual system is the fastest way, maybe the auditory system as well, to down regulate your arousal, and the answer ... the reason for that comes from neuroanatomy. So, here I teach neuroanatomy to the medical students, and there are two ... there are multiple cranial nerves that feed the so-called reticular activating system, this wake-up system for the brain, but the two that people often overlook are cranial nerves two and eight, which are the optic nerve, and the vestibular auditory nerve.

Andrew: So, if you recall, the optic nerve was the primary evolutionary anciently installed mechanism to control arousal. And now you consider that the human brain is 40% for vision, and now it makes sense why. Okay, of course you want to block blue light in the evening, because that optic nerve, that second cranial nerve is carrying arousal information to the brain, and if you stimulate it with blue light, which it's susceptible to in the evenings of course, and too strongly, you're going to shift your clock. So, our ancient brain used vision as one of the primary drivers for controlling autonomic arousal.

Dave: It's interesting. I went through this period, geeze. This must be about 10 years ago, where I was working with a developmental ophthalmologist. And he had me do all sorts of crazy exercises that, over the course of three months, I went from 20/60 in both eyes, back to 20/15. And I got rid of astigmatism, and to this day I'm still 20/15. And I had drifted, so I was like 20/60, 20/80, something like that. So, it was kind of magic. But it was an hour of weird vestibular activation exercises. I was exhausted for the whole day after I did these. It was really terrible brain stress, to be honest, but one of the exercises that made the biggest difference, and something that I'll still do today if I need to, is you rub your hands together, like the way you would like in Qigong, and then you cup them over your eyes. And just open your eyes, but all you can see is darkness.

Dave: And if you talk to Doctor Barry Morguelan, the Chinese energy master, UCLA surgeon whose been on the show a couple times, he's like, "Well, there's special chi that comes out of rubbing your hands", but you talk to a neuroscientist like you, you're saying, "Well, covering the vestibular system allows the brain to relax, and allows the eyes to relax. And maybe is triggering that relaxation system. So, I mean I've taught people to do that, for anxiety. But I think you've got at mechanism for what's happening there.

Andrew: Yeah, really. It makes perfect sense. I mean, I think that I, as you know, I don't shy away from the notions of yoga or meditation, or [inaudible 00:29:42], right?

Dave: Hold on a second, can you be a modern neuroscientist and just completely dismiss all that stuff? Has it shifted that far?

Andrew: Well, you know, it's interesting because I mean, people vary. My colleagues here are very open minded. People vary in the extent to which they do these things. I think there's a new generation of people coming up who are exposed to ideas, who care about ... who realize that their nutrition impacts their health. I mean [crosstalk 00:30:05].

Dave: Or their brain.

Andrew: Yeah. I've been very sad to see colleagues who didn't manage their health ... Well, here at Stanford, people tend to be pretty health minded, but who didn't manage their health well, who are ... some of them were studying cancer, of all things, right? And so, you see this where people have studied psychiatric illness, and then commit suicide. I mean, it happens. And the reason is that we're all myopic, we're all near sighted in some way. We all have our blind spots. I think that what's so economy nowadays, and this is

something I care very much about is the field of neuroscience is in a position to bridge in a logical rigorous, and yet open minded way, to the fields of wellness and these more kind of what used to be niche fields, like yogic practices, and things to that sort.

Andrew: I mean, it can't be overlooked. And one reason why I love running my labs so much, and one reason why I also am so interested in these fields of wellness and biohacking is because I think growing up in this area, I really got to see how computer science and engineering, and physics that was once the domain of academics, eventually made it into companies like Apple and Google, and all these incredible companies. And I think the same thing is going to happen in neuroscience. I think it's happening now. It's starting, where the career options and the paths that these really smart hardworking scientists and really smart hardworking people in the wellness communities are going to start to merge through, and I'd like to serve as a bridge so much as I can for information in other ways, to keep the flow of information bidirectional.

Dave: Andrew, you said something really important, you said a lot of researchers or physicians, or academics, that they're blind to ... or they're myopic, or they're blind to certain new ideas. You've actually spent probably more of your career than anything else, actually studying real blindness. And you actually said, "I plan to give my entire life to the study of the visual system," in one of your interviews with the Glaucoma Research Foundation. So, you're one of the top eye-brain interface guys out there, and you're actually working on curing blindness. Why do you care so much about blindness?

Andrew: I think it's because we're just such visually driven animals, you know? I mean, I love music, but if you took away my hearing, I'd be all right. Smell, I could do without. You know, we have all these wonderful senses, touch is obviously key, but we're just so visually driven, and I think it was early on, I was raised in visual system neuroscience meaning my graduate advisor was in the lineage of these two guys, David Hubel and Tornston Wiesel who won the Nobel for discovering critical periods, this idea that you could ... your experience during particular phases of life dramatically shaped the brain. It's like duh, now. But in the early '80s, that wasn't necessarily ... it certainly wasn't known, it wasn't data-supported. They did that.

Andrew: So, they're my scientific grandparents, or great grandparents. But I've always been fascinated by vision. I grew up with a kid who went to our school, this kid Tony, and he walked with a cane. And I remember having a very strong emotional response to that. It was just so clear that he wasn't going to be able to do most of the things that anyone else was going to do. And I think it hit me at kind of a gut level. I never knew that I'd get, at that point, that I'd get into visual neuroscience, but I also ... but I know how ... I felt how important the problem was, and then later, my lab was working on develop of the visual system, and I thought, "Well, this is great, but we've got to apply some of this to regenerating the visual system."

Andrew: So, there was a wealth of knowledge, from our lab and other labs on how the eye connects to the brain and vision takes place, and I felt like look, the time is now. So, we published a paper back in 2016 showing that specific patterns of electrical stimulation using screens, not wires, but having mice view particular patterns of visual stimulation could actually enhance regeneration after a blinding injury. And I got contacted by

hundreds, now thousands of patients around the world, like, "Can you help me? Can you help my kid? Can you help my wife> this is so debilitating, I'm losing my vision." And so, what I decided at that point was this kind of ... the typical line of oh, it's going to be five or ten years before we do this in humans, more studies in mice, more studies in mice, I thought, "You know, enough of that."

Dave: If you're blind, more studies are not needed.

Andrew: Right, exactly. Right. Exactly. So, I thought, "What is a safe and non-invasive way that we can bring this to humans now?" So, one of the things I'm most proud of, and this was a team effort of course, and I rely on excellent people here at Stanford and elsewhere, but was to take the timeline of running ... taking a result like that to a clinical trial in humans, typically it's five to ten years, and we made it ten months. So, right now, we're running a clinical trial with the ophthalmology department here at Stanford, where there are patients, it's a small number of them still, but we're growing that number, who have VR headsets that they wear, put on five times a week for a 30-minute training to stimulate the retina in specific ways in order to try and get enhanced vision so that they can see better.

Andrew: And for people who are losing their vision, and this is key, for people that are losing their vision, to not lose their vision. So, to hold onto what they've got. Because it's one thing to cure blindness, to reverse blindness, but in many blind diseases, it's slow. So, like in glaucoma, it's really slow, and so we are making a serious effort to halt their vision loss, and I can't ... It's a clinical trial, so I can't report the results yet. I'm also blind, no pun intended, I'm also aware of that the results in many cases in order to keep the science rigorous. But I'm excited about where it's going. I'll just say that. And of course, the data or the data. But-

Dave: I've got to ask you-

Andrew: ... there's so much about it. You know?

Dave: Do you go home at night and put those VR goggles on to give yourself super vision?

Andrew: No, but I've become very ... no. I don't do that.

Dave: Can I? Will you hook me up? Hook a brother up.

Andrew: Sure, I can hook you up with the code, and the stimulation is actually kind of fun. We have people forage through a virtual art gallery, so you can learn art while you do this.

Dave: Wow.

Andrew: You have to make the stuff interesting. If you're going to do something five times a week for 30 minutes, we had to make it interesting for the patients. So, we designed a virtual art gallery that the patients go into, they view these empty frames, which are boring, but then they see specific patterns of visual stimulation, and then as a reward

for that, they then get exposed to different ... they see these different paintings, and they're learning the paintings. And as they get ... and we're using that as a measure of their visual perceptual abilities too, so yeah. I'm happy to tell you what we're doing with it, supply you with what we've got. You know, the VR technology has expanded so fast, I don't think VR is going to be one of these things that is going to take over every industry like people predicted it would, but I think for clinical treatments, it's extremely valuable.

Dave: One of the things that fascinated me when I got really into my visual system was that my left eye would actually turn off. So, I would not see in stereo vision, but I didn't know it. I was blind to the fact that this was happening, so my brain would get tired, my visual system was stressed, my eyes didn't team well. So, I worked really hard on turning that eye back on so that I would have both eyes working the same time, and really training the brain to cause them to work together. The theory that they came up with was that I started reading when I was 18 months old, so I probably spent a lot of time staring at a page instead of looking at trees and crawling around, and stuff.

Andrew: Yeah. Absolutely. Wait, how old were you when you did this retraining?

Dave: I was about probably 34 is a guess. 33, 34.

Andrew: So, I mean, that's an amazing story. That's awesome because the classic thing, that Hubel and Wiesel on Nobel prize was for this idea that the brain is plastic early on and then it's kind of frozen these critical periods. But the work that-

Dave: Yeah, well Eric Handel came on the show, the guy who discovered neuroplasticity, right, right.

Andrew: Oh, yeah. No, I mean, I think that one of the great sequels to that was these people like Handel, like Eric Newson like Mike Merzek, whose shown that no, that it's an absolute no. It's not just restricted to early life. That if you pay attention to the task that you're focused on, so this is getting into the realm of adult plasticity, if you pay attention to the task and you have sufficient level of autonomic arousal, or alertness, right? Sympathetic arousal, then the neuromodulator dopamine and acetylcholine, nicotinic receptors are stimulated by the acetylcholine, when you talk about nicotine, right? You're a fan under certain regimes. Then you open up plasticity. You essentially amplify the conversation between particular neurons that are involved in that sensory event, like viewing something, or conversation or whatever it is.

Andrew: And then you get long-term plastic changes in that circuitry. And I think nowadays, in 2019, it's absolutely clear that adult plasticity is not only possible, it's available, just provided you engage in the particular learning bouts. They have to be short, they have to be focused, they have to be repeated and it does help if there's some neuromodulator augmentation. Now, that's not for everybody, right? I personally believe not everybody should be chewing Nicorette or whatever, but there are-

Dave: Absolutely not.

Andrew: But there are conditions in which that can potentially enhance plasticity. You know more about that topic than I do, but the plasticity in adulthood is very real, and you're a really great example of that.

Dave: I'm really interested, because I'd love to put on a virtual reality goggles and have it over weight my left eye to stress that part of my brain so it would become probably even better than it is, because I know that I have a perceptive weakness there. And I imagine a substantial number of people have one eye that's a little bit weaker than others. And we've had Helen Irlen on, who talks about this stuff. So, I know we could do that with VR, and I'm hoping that you are ... some of your friends are doing that. But the flip side, I'm a computer hacker, by background, by training, and I think about what happens if you have malware running in VR goggles. Can I change the flicker rate on just the left eye versus the right eye? I mean, could you trash people without them really knowing it?

Andrew: Yeah. I mean, if someone had ill intent, they could do that, sure. I think-

Dave: That's actually kind of scary. I mean, if you're playing games with the VR for six hours a day, and there's a 5% tweak between your two eyes, over time that could be a substantial performance improvement, and you would have no idea why.

Andrew: Right. Well, I don't think anyone should be spending six hours a day in VR. Jeremy Bailenson a colleague of mine here at Stanford, wrote this book *Experience On Demand*, and is a ... he's been in the VR field essentially longer than anybody that I know. And he has some very specific prescriptions, especially for kids whose brains are very plastic, because there's ... Look, one hour or two hours of a patched eye of just occluding, or closing one eye in childhood, can lead to a permanent shift in the brain representation of that eye. You can become cortically blind to that eye, unless you do the reverse experiment, which is to cover the other eye and open the one that was recently closed and reverse it.

Andrew: That's the kind of work that Hubel and Wiesel won that Nobel for. So, the rewiring that you can have in adulthood is more subtle in any one session, but that's why you don't want to be spending six hours a day in VR, or I mean, it's not clear you should be doing six hours a day of any one thing in particular except maybe sleep, right?

Dave: There you go. I like that quote. What about we'll just call it human augmentation? About going beyond what we were born with. You've done your scuba, you've done some pretty extreme sports sorts of things over the years, what's your take on it? Is it real? Is it happening already? Is it going to happen? What does it look like?

Andrew: It's going to happen. It's happening. There are some people out there that are claiming they're going to put chips in the brain, get people learning languages in a few days, enhancing, da-da-da, you know? Here's the deal, at this point in the sort of history of neuroscience, we understand a thing or two about sensation. The neurons involved that beget sensation. A thing or two about perception, a thing or two about emotions, although emotions are very poorly understood, frankly. A thing or two about thoughts,

well that's very poorly understood, and action we know a thing or two about. Because you can measure it, right? Now, that means that what the brain is doing, the so-called neural code, is mysterious. So, there have been a lot of recordings from the brain, so-called when people say reading the brain.

Andrew: You're sort of like what are the signals, when are the neurons active in space and time during a behavior, a thought, et cetera. And then there's writing to the brain. They're actually manipulating the neurons and their activity. Well, we don't know what the algorithms are that lead to, say, if I say, "Okay ..." Have you ever had a pet, Dave?

Dave: Oh, absolutely. I have a Dachshund named Merlin.

Andrew: Cool. So, just that conscious recollection of his name, and his or her name, and the ideas of Merlin, there's so much context. Right? We don't really know what the symphony of neuronal activation is for that, such that we could manipulate it and change your relationship to it. The things that we're getting good at, as neuroscientists, and as biohackers, are manipulating that arousal state. I'm fascinated by all the stuff, all the concentration of breath work, and ice baths, and ketogenic diets, and all this stuff. These are all things really designed to manipulate arousal state. And then you've got the stuff that's targeted at cognition, per se. Like nootropics and things of that sort. There's a really more your wheelhouse than mine, but I watch the field and I try and place it in neuroscience context.

Andrew: The people that are talking about creating super beings that can learn so much, and retain so much. You know, I invite a challenge. I'm delighted that people are thinking about neuroscience, but without any understanding of really how to think about emotions, in a rigorous scientific way or think about thoughts in a rigorous scientific way to really understand what those are. I'm not all that confident that people know what sequences of stimulation to put in the brain in order to get it to be 10X better, or 50X better at any one thing. However, I will say this, things like you mentioned TMS, there are laboratories that are now using 10 hertz stimulation, not inhibition, or inactivation, but activation. 10 hertz activation in particular circuits to open up the window for plasticity-

Dave: With magnets? Or electricity?

Andrew: With TMS.

Dave: Oh, with ... okay. So, I have a neuroscience facility, not quite up to the Huberman lab standard, but we have two neuroscientists, and a lot of EUG stuff, but we'll actually use very specific frequencies with an alternating current across the brain, including 10 hertz was one of them. But we'll do that to increase neuroplasticity before doing neuro feedback so that you can get basically that more results in less time, right? And I've been doing that kind of stuff. Well, the alternating current now going on 20 years, in different frequency sets. But you're doing it with magnets, which we'll also use pulse magnets actually, in those frequencies, but they're very weak compared to what you're talking about.

Dave: I'm a little frustrated, the Russians started doing this in the '60s. That's how come I know about it. It was in the Russian Space Program. And it feels like transcranial stimulation, TDCS, about eight years ago when I started blogging, I wrote a lot about how to do it yourself. I've sent it out in the quarterly curated box I do, and I look at biohackers are doing that one thing, but we have 50 years of using electricity, or in some cases magnets on the brain, but it's almost unheard of. You've got Halo Neuroscience out, maybe doing it. Why does it take 50 years for this stuff to come out? Do you have a sense from the inside of academia?

Andrew: Yeah, so I think ... yeah. So, there are people using 10 hertz stimulation, trying to open up windows for plasticity. It can be done. Why? Okay, the reason is that failures in neurosurgery and in medicine can halt fields entirely. So, like if you look at gene therapy, right? There were some early failures that set back the field of this powerful thing of gene therapy, of using viruses to deliver genes that people need into their body and brain in different ways, set it back a decade or more. The medical community is very reactive, right? Like the Fen-Phen thing, why people were losing weight, and people started dying. It's like gone, right?

Dave: Right.

Andrew: Tryptophan, right? You know, it's like now you can go by 5-HTP or tryptophan at your health food store or online at Amazon, but you know, it used to be that because of a contaminated batch of tryptophan and some people died, it was like, tryptophan was off the market. So, people were relying on heavier sleep medication when they probably didn't need to. So, there's a tragedy as a result of that ban, right, too. So, I think people are reluctant, but it's changing. I think that brain machine interface is going to be the first place, non-invasive brain machine interface-

Dave: Can I high five you for that? So, the non-invasive part of that, [inaudible 00:47:22], there's the Elon Musk neural lace idea that we're going to have these implants in our brains. My wife, Doctor Lana, and I started a company that did a lab testing for immune rejection of implant materials that are supposed to be hypoallergenic, and so we went kind of deep on that. This was in the mid-2000s. And I'll tell you, there were people who were allergic to titanium, allergic to gold, things that you're not supposed to be allergic to, and then you have bio films in infection, and I'm pretty out there. I mean, I've had stem cells everywhere, and did all sorts of stuff that ... I've swallowed electrical stimulation devices. But I am not implanting crap in my brain until we've managed to get all the signal out of our eyes, coming off our brain.

Dave: And there's just so much that's not touched. It feels foolhardy and stupid, and like you read too much sci-fi, which is almost impossible to do in order to think, oh, we've got to drill holes. And I feel like I'm almost like a heretic for saying that, but you said non-invasive before I did, so why are you in the non-invasive camp versus why shouldn't we all just go get a chip?

Andrew: Well, I think because I'm realistic about what's going to ... most people are not going to breach the skull. They're not going to take a little drill to the skull. You know, neurosurgeons aren't afraid of drilling through a skull. They love it, they live for it, they

train for it. And so, they're the first people to say, "Oh yeah, you know, it's no big deal." But they do it with a purpose. Now, I think that there is this portion of your central nervous system, the brain, right? The only piece of your brain that sits outside of your skull is your retina. And so, I'm obviously, I keep coming back to this, but I'm making a push for the visual system as an entry point for at least manipulating states, and for accessing the spirit of courage transition for accessing control over stress in real time. I'm not an engineer. I'm not developing the technologies to do this. One of the reasons I was excited to come on your podcast is because people listen to it.

Andrew: I think that there are smart people out there that can create science grounded tools for this.

Dave: Oh yeah.

Andrew: And remember, that's a piece of the brain hanging out outside the skull for which the statistics and the ... in other words, the stuff you want to deliver to the retina, and I don't mean injecting into the retina, I mean looking at stuff, or seeing certain things, is kind of known. It's not like you have to go find some substance in the amazon. It's called light, you know? And you just have to manipulate light, either in VR or in another format in intelligent ways. And I think that ... So, that is one form of brain machine interface. Now, Halo's and interesting one, too. I think the founders of Halo, one of them, trained with Mike Merzek. I've never tried the device, but-

Dave: They came on the show. It was pretty cool. Yeah.

Andrew: Yeah. I mean, it's grounded in very good logic. I received nothing from them, but I think that the logic is great. Stimulate [inaudible 00:50:06] post-synaptic activity, activity in the motor cortex, while engaging in a motor [inaudible 00:50:11] want to learn better, get a little more or much more amplification of the signal, and learn things faster. It all makes sense. I think that the stuff that you're doing of ... I haven't tried all the tools. I'd love to, next time I'm in Santa Monica, I'd love to try some of the tools and get to use it.

Dave: We'll hook you up.

Andrew: The pods and all this stuff. But I think very few people are willing to take an intelligent, thoughtful engineering approach to this. You know, on the one hand you've got scientists that are busy running their labs, trying to figure out how things work under normal conditions and solve disease and stuff. And then you've got people in the biohacking community who are like, what one pill is just going to get me there? And I think, I'm not just saying this because we're in conversation, I think embracing the brain machine, the non-invasive stuff, the supplementation stuff, the whole of it is the only way to arrive. It's a whole field, right? It's like saying the field of neuroscience couldn't have gotten by with just an electrode. You also need an atomist, and a molecular biologist. The field of biohacking and wellness, you need people who are thinking about different domains of the problem. And you're doing that, and there are others of course, too.

Dave: You nailed it. When I created that community and in the term ... in fact, they added biohacking to the dictionary in 2018, in Miriam-Webster's. It's a new word in our language-

Andrew: Is your name in there?

Dave: Yeah, it is.

Andrew: Are you serious?

Dave: I'm serious. I was blown away. Someone texted me. I'm like-

Andrew: I always say the moment you become a verb, then you know. It's like Marie Kondo now, they're talking about you're going to Marie Kondo that, so pretty soon you're going to ... we're going to call it Bulletproofing it?

Dave: It's just called biohacking. And I actually didn't trademark that word, because I wanted there to be a name for how to do, we bring neuroscientists and Navy SEALS, and deep-sea divers, and weight loss experts, and all the people who didn't ... and bodybuilders, for God's sake. They would never talk to neuroscientists, but they're really, really good hackers of our human biology-

Andrew: They're willing to try most anything.

Dave: Yeah. We need guinea pigs who want to look like balloon animals. I'm just kidding. But if you want to get real swole. But I wanted that, and you just hit it on the head when you talk about you won't get there with just one, because I used to try just one of those when I ... I had a lot of work to do, because I was pretty much wrecked. And it kind of makes me mad when people like, it's just that one pill. It's like no, you can't eat garbage and take the one pill. It doesn't work. Right? And if you just eat really cleanly, and you think that's going to magically give you all the performance you can do, well that's not going to work either. You just have to stack it, but then it's actually work. And sometimes maybe you need more arousals so you'll be on fire to do the work.

Andrew: You know, it's interesting because I think that right now, we're at such a key point in the evolution of, not just neuroscience, but this biohacking field. I think that it's no longer niche, and there are a number of scientists who really ... I heard a great podcast, it was with Rogan and David Sinclair on aging, you know?

Dave: Oh yeah. I've been following David Sinclair's work. In fact, some of the people who've shown some new things about nicotine, [inaudible 00:53:02] that were going to come on soon. So yeah, okay. So, yeah.

Andrew: Yeah, I mean guys like Sinclair, he was willing to at least talk about what he's doing in his own life. He cares about his longevity and his health. You know, there is a new generation coming up, and we're ... I mean, I've been in this game a while, because I got into it young, but we want to live long, healthy, better lives. I approach neuroscience

and my career in neuroscience, I looked at it and I was like, "Look, I'm not a professional athlete, but this is as competitive and time consuming, and energetically demanding and potentially stressful as anything else, and it's professional, and this is my livelihood."

Andrew: So, my nutrition, my supplementation, my exercise, my whatever brain machine interface that will happen [inaudible 00:53:44] done less of that, was all geared toward trying to be better at what I do, right? And live my normal life outside the lab. But, so I bio hack my way through neuroscience [inaudible 00:53:54].

Dave: Yeah, but that's why you have a position at Stanford, because that ... And that came out really well. *Game Changers*, this last book, I asked 450 people who did something noteworthy enough to be on the show, the same question. And found the common patterns of what they did to become prim and at what they do, and well, what you did to become at the top of your field is very similar. There's common patterns, and one them is ... in fact, the number one answer out of all these interviews when I had a statistician go through the data with me, it was actually food. And a surprising number of people realize that when they eat crap, they just don't perform well at what they love to do. And then, they know. But then from there it goes all over the place. Which is fascinating. So, you've somehow knew that, and I have two more questions for you.

Dave: One is, how did you know to do that? Like did you a have weird parents who were hippies, giving you drops of herbs? Did you have .. that's a rare human thing to just evolve into.

Andrew: Yeah. Honestly, it was because of a girl.

Dave: It always is.

Andrew: It was. I mean, the short story of it is, you know, I was a kid in high school, skinny skateboard kid, and I was ... there was a girl a couple years older than I was, and I had heard I might have a chance, or she might've looked in my direction for a millisecond or something. You know, I fell in love young, followed her off to college, and I ... So, I got into fitness first. I was like, "All right, I'm going to start doing my push-ups, and sit-ups", and that kind of thing. And then you get into that community, and pretty soon you discover oh, how I eat impacts my body and how I feel, and how I think as well. And over time, I got really interested in nutrition and supplementation.

Andrew: I always wanted to try out different things. I found I do best personally on limiting my starches, and eating more fats. I was lucky that my dad is Argentine, so he was always like, "Look, you want to eat meat because it's important." This was in the '90s, right? Because everyone was on these low fat, low protein diets. So, and I felt like I could outwork people in terms of longevity. Like in time, everyone else was crapping out, and I'm still going. And then I could use ... I learned pretty early to use exercise to change my schedule. So, if I need to be alert in the morning, I start exercising in the morning. I can shift on jet lag that way.

Andrew: So, I started biohacking early on, and frankly I loved supplements. I think it taught me to be in tune with my body. I'm very sensitive, so-

Dave: How many a day do you take?

Andrew: Oh man. So, the joke of one of my friends and colleagues is when people say what do you take, my response is just all of them. I have the things that I take. If you looked at what I take, that most of them-

Dave: I'm kind of thinking like it's got to be number, because I feel like ... I do 150 pills a day, so to list that would be the rest of the show.

Andrew: I'm probably somewhere in that regime.

Dave: Okay, but you take fistfuls basically.

Andrew: Oh yeah. I mean, yeah. Fistfuls, easily. And I'm a big fan of ... but I'm very systematic. So, I've got my stack, I'm always happy to share that with people, but that's just what I do. I've got my stack, and then I systematically try new things. And I can tell very quickly if something doesn't work for me or works for me. Everything I get you can get off Amazon, it's typically. So, I don't take anything really esoteric, but I've long taken things like desiccated beef liver tablets-

Dave: Oh yeah, me too. For years.

Andrew: Yeah, this kind of thing. I mean, multivitamin, ginger, these kinds of ... but you know, so I eat pretty normally, except pretty clean. But you know, I think in general, the supplementation has given me, I would say, it's hard to put a real number on this, but anywhere from a 10 to 25% advantage. In terms of, I just look at colleagues and they're like ... intentionally they're dropping out. Or I see them on for a meeting. I don't mean here at Stanford, because there's some superpower people here, of course. But they're on for the meeting, and then you walk away and they're kind of like, "Oh." Or you see them five years later, you haven't seem someone in like a year, you see them in a meeting, you're like, "What happened?" You know? They're like falling apart.

Andrew: They're talking about their this pain, and that pain. I'm like ...I'm 43 now, and I put time and energy into it. But I think it makes me happier and it makes me better for my work.

Dave: The ROI on that is exceptionally high, and there's an infinite number of things you can do that would take all of your time, but over the course of practicing them, you figure out this one was worth it, and this one wasn't. And that's the path of biohacking. Final question for you.

Andrew: Yes, sir.

Dave: I've been running an anti-aging non-profit group, actually one that meets in Palo Alto for almost 20 years. And I've learned from people three times my age, at least back then.

Three times my age now is getting up there. But I have been real public, in men's health recently, it's like look, I'm going to live to at least 180. Here's the math. Here's why I think I can do it. And that's pretty far out there. But you're a biohacker, you're a neuroscientist, you're very well trained, you know what's going on up there. How long are you going to live?

Andrew: That's a really interesting question. I actually believe, and I've felt this for some time, that two things. One is that we have a kind of intrinsic sense of how long that is, without any intervention. I think we can sense it, although we have family history so that gets in the way. I have a theory, and I am not ... this is not grounded in any data that I've ever collected. But I have a theory that how protracted or prolonged your puberty was is a good predictor of your longevity. And now, probably someone out there is like, "So and so said that 20 years ..." Okay, yeah. I get it. I haven't read the literature, I haven't Pub Pub-Med-ed this in detail, but I usually take a look every once in a while.

Andrew: You know, the men in my family have lived very long times. They've aged slowly. I hit puberty at like 14, like many kids at that age. But it was very protracted in terms of the acquisition of what they call secondary sex characteristics, right? And I think that right now, I'm aiming for 100, but the key ... but I'm willing to expand that out. But this year, on my birthday, I went up to Clouds Rest, this peak up in Yosemite, did my age in pushups, and I plan to do that every year.

Dave: Nice.

Andrew: I'm more determined to prove that you can get better every single year, because I feel better-

Dave: Because you can. Like you can get younger. It's totally there.

Andrew: I literally feel better, and I can perform better every single year. And I think there are levers to make that go better, of course, and you know more about that than I do, but I'll put ... but just to be optimistic, I'm going to say 120, and-

Dave: You just added 20 years right there, all right? That's what i like to hear.

Andrew: Well, yeah. 120 because I feel that 100 is without intervention.

Dave: There you go, okay.

Andrew: Yeah. 100 without intervention, and I'm gauging that on a ... I believe that we have clocks that allow us to get some sense of how long we've got to go, barring accident or injury of course, right?

Dave: Right, right.

Andrew: A bus doesn't care about your genetics, right? You step in front of a bus, you're done. So, if it's moving. So, but the ... and I'm not suggesting one do that, of course. The

opposite. But I think that the ... I think we have a sense of our arc, and I think the duration of puberty and the acquisition of ... the speed and acquisition of secondary sex characteristics is an interesting potential predictor of that arc.

Dave: Beautiful.

Andrew: That's my answer.

Dave: Andrew, thank you for your work. You're doing really fascinating stuff across a diverse spectrum of neuroscience and neurobiology. And for people listening, you've got to check him out on Instagram, he has one-minute neuroscience lectures. It's at Huberman Lab, is where that stuff is. And I really appreciate both the depth of your work, but also the fact that you take the time and that you have the ability to share it in a coherent manner, because there are a few neuroscientists, probably some guys you and I both know, who are doing profound work, and they can't tell you what they're doing because they don't have that in. So, just thanks for being a good storyteller about your work, and just for doing the actual hard stuff that you do.

Andrew: Well, thanks so much for the kind words, and for hosting me. I'm a huge fan of the work that you've been doing, and are doing, and it's really, for me it's very gratifying to get a chance to talk about these ideas with you, and share them with your audience. So, thanks ever so much.

Dave: If you liked today's episode, you know what to do. Check out Andrew's work on Instagram at Huberman Lab. And while you're at it, if you like the show, and you haven't had a chance to pick up your copy of *Game Changers*, I'm going to buy you 500 hours of life. If you were to listen to 500 episodes of Bulletproof Radio, which is going to take you approximately three months of your life working 40 hours a day, and there are quite a few people who have done that, but if you haven't done that yet, I went to the trouble, I went through every episode, gathered the knowledge from them, looked for commonalities, sorted through it, and made it so that you can read the book, or listen to the book, you can read it in about four hours, and you can get all of that boiled down knowledge with the simple question is what are the things you can do to perform better as a human being?

Dave: Not by following one guru or another, but saying, "What do they all agree on? What are the common patterns?" So you can pick the things with the highest return for you. This took me more time to write than most of my other books, and it's not a here's episode one, here's what you learned. It's a real study of Bulletproof Radio. So, check out *Game Changers* if you haven't. It's almost entirely five star reviews. The best reviewed book I've ever written. It just hit the shelves, and pick it up today.