

The value of math and spatial learning with Loren Frank

The Howard Hughes Medical Institute investigator discusses what drew him to study the brain and his current work at the University of California, San Francisco.

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This transcript has been lightly edited for clarity; it may contain errors due to the transcription process.

[opening theme music]

Brady Huggett

Hello, this is “[Synaptic](#),” our podcast here at *The Transmitter* that looks at the people, the research and the challenges of the neuroscience field. This is Episode 12 of our show. We’ve reached a dozen now. I host “Synaptic”; my name is Brady Huggett, and thanks for joining.

[transition music]

Brady Huggett

All right, today let’s go way, way back to 1587. That places us firmly in the Renaissance period. Let’s go to Italy, and let’s look at Julius Caesar Arantius. Now, I’m probably mispronouncing that name, but that’s my best attempt. Anyway, in 1587, Arantius, who was an anatomist and a surgeon, published a book titled “De Humano Foetu Liber,” now I’m probably butchering that as well, but in English that translates to “On the Human Fetus.” In this book, Arantius described for the first time a structure in the brain that he felt resembled a seahorse.

In Greek, the word for horse is hippos, and the word for a sea monster is kampos. He called this structure the hippocampus. There were other names proposed for this by other people, and you can look those up if you’re so inclined, but in the end, hippocampus is the term that stuck. Hundreds of years later, at the University of Arizona, a man named Bruce McNaughton was running his neuroscience lab. In 1993, a college student named Loren Frank inquired about working with McNaughton during the summer break.

McNaughton had a postdoc compiling a database of the various cell types in each subregion of the hippocampus, including the relative frequencies of each cell type. It was there that Loren Frank was introduced to the hippocampus, “a structure I had never heard of,” as he says in this podcast. It was during that summer that Loren says he figured out exactly what he wanted to do regarding his career. That is our guest today, Loren Frank. We talked about his fascination with the hippocampus on this podcast. We also talked about his time at MIT, where he was failing a project so miserably that he thought he might wash out of neuroscience altogether.

Of course, we talked about relay events and how memories are formed. All of that and more coming up in the next hour. I interviewed Loren on February 17th on a Saturday at his home in San Anselmo, north of San Francisco. It was an overcast day with light rain coming down when I arrived. His house is up this winding road with a wonderful view of the surrounding hills. There’s lots of greenery. It seems almost rural, to be honest. Loren said that they feel very lucky to live in a place so bucolic while still allowing him access to his job in the city.

We sat in a lower floor in his house with his family upstairs, and that included the dog. I put mics on a table between us, and we got down to business. Loren is really easy to talk to, and he’s sort of honest and self-deprecating in a way that I found actually very funny. Maybe you will too, I don’t know. Anyway, that should be enough to get us going. Let’s start here, where Loren is talking about how he gets from his home to the University of California, San Francisco, where his lab is. The commute includes riding his bike and also taking a ferry. Here’s your episode of “Synaptic” with Loren Frank, starting right now.

[transition music]

Brady Huggett

Is there a Wi-Fi signal on the ferry?

Loren Frank

Ah, fortunately, no, but the tethering to my phone works almost all the way across the bay. I pretty much have consistent Wi-Fi access the whole time, which is helpful. Sometimes when I don't, it's even better, because then I can't do anything other than longer timescale work stuff.

Brady Huggett

What does that mean?

Loren Frank

Oh, like working on papers or writing letters or grants or whatever else-

Brady Huggett

Something that is not tied to the internet.

Loren Frank

-that doesn't actually require immediate online access.

Brady Huggett

Are you unplugged in that moment?

Loren Frank

For that moment I'm unplugged. It's a short moment, though, right? Most of the time I'm plugged.

Brady Huggett

We're going to talk about that, because there's a couple of things in your research that-- Anyway, [crosstalk]

Loren Frank

No, about the offline replay and what that might be good for and whether these periods offline are actually really important, potentially.

Brady Huggett

That, and also the way the media has perceived that.

Loren Frank

I learned a lot about media interactions from the way that that spiraled in various directions.

Brady Huggett

OK. I'm going to get to that, because I was fascinated by it myself. Let's go back to the beginning. We're in San Anselmo. As I said, it's an incredible view. It's foggy today, but you can see these rolling hills. It's gorgeous up here.

Loren Frank

It is a truly beautiful place, and this is a place where, for better or worse, they set aside a large fraction of Marin County as conservation land. The hiking, mountain biking here is quite extraordinary. It also means, of course, the property values are also painful, etc.

Brady Huggett

Sure. Yes. That would go hand in hand. From here, can you go out and- Are there paths that you can pick up and hike around in this area?

Loren Frank

Yes. We can hike up to our local hill. We can drive across the valley and then hike for as long as we like along the ridges on the other side of the valley. Then other things, mountain bike trails and so on, are easy to get to.

Brady Huggett

How often do you do that? Do you spend your weekends here?

Loren Frank

Almost every Saturday, except today, I go out with my boys and we do a hike somewhere. Then some Sundays, I go mountain biking with a friend of mine. Not every Sunday. It sort of depends on the weather.

Brady Huggett

Mountain biking, like BMX downhill?

Loren Frank

Cross-country, yes. I'm old enough that I try not to do large jumps and things anymore so I don't hurt myself, but real mountain biking trails.

Brady Huggett

It's like the age wisdom.

Loren Frank

Yes. Something like that, and I don't like hurting myself.

Brady Huggett

Who does? You have two kids?

Loren Frank

Two kids. Two boys, Aidan and Nathaniel, 18 and 13.

Brady Huggett

Aidan's 18?

Loren Frank

Yes.

Brady Huggett

He's quite tall. You're not from this area. I know that. I think you were- I don't know where you were born, actually.

Loren Frank

I was born in Albuquerque, New Mexico. I spent the first 17 years of my life there and then wandered up around the country to finally end up here in the Bay Area.

Brady Huggett

You were born there. Does your family have a long lineage there?

Loren Frank

No. A slightly amusing story. We'll see if this is too long. My father had worked- He was a psychiatrist at UC Boulder, sort of a campus shrink, as he described himself. He ended up moving to the University of New Mexico as a psychiatrist there. My mother was coming through, I believe she had recently come back from Moscow as a tour guide for an American exhibit in Moscow for the RAND Corporation. This was in the height of the Cold War. She came through Albuquerque and met my father at a cocktail party. I don't quite understand how exactly this happened. That clicked. They spent a total of 26 days together after that meeting over the course of the next six months and were married. That was-

Brady Huggett

Six months after they met, they were married.

Loren Frank

They were married.

Brady Huggett

After spending 26 days together.

Loren Frank

Then she moved to Albuquerque, New Mexico, where she had no previous plans of being. That was where they ended up.

Brady Huggett

Your father, where's he from originally?

Loren Frank

My father was originally New York, actually. He grew up in New York City, spent his summers in New Hampshire. My mother was a Holocaust survivor who was in hiding during the war in Holland and came over with her family with sort of nothing, started in St. Louis. She actually was sort of an au pair or a live-in au pair for a Hollywood director who sponsored their family. She went to Beverly Hills shortly after coming here after the war and spent some time there helping with his kids.

Brady Huggett

Your mother was a Holocaust survivor?

Loren Frank

Yes.

Brady Huggett

She's still alive.

Loren Frank

Yes, she's 88.

Brady Huggett

Oh my God.

Loren Frank

She just turned 88.

Brady Huggett

Wow.

Loren Frank

Yes. Remarkable. She lives with us. She's upstairs behind me. She's an amazing person.

Brady Huggett

Have you obviously talked through that history?

Loren Frank

Oh, yes. No, we know it; my children know it. She actually still does talks to people around here about the Holocaust, about the lessons she's learned from it, things like that.

Brady Huggett

We're already off topic, but I don't care. Some poll just came out, a shocking number of people 30 and under think that maybe the Holocaust is not real. Is she aware of that?

Loren Frank

Yes. Yes. This is part of her going- she goes to schools actually and gives talks to the kids there sometimes. I think the reality denial that we're seeing in all aspects of our society has been growing tremendously. It is clear that things that are out of mind now, and there's not a lot of history left apparently in the curricula to make these things clear. Yes, it's actually totally terrifying.

Brady Huggett

It just feels like if they made everybody go to Auschwitz and tour it, that thought would go away.

Loren Frank

I agree. I agree.

Brady Huggett

It's shocking. Is your dad Jewish?

Loren Frank

No.

Brady Huggett

No. OK.

Loren Frank

No, not at all. Non-religious growing up. I was raised with a little bit of Judaism on the side, but not seriously.

Brady Huggett

So he's in New York.

Loren Frank

Yes.

Brady Huggett

He gets the job eventually at Boulder as a campus psychiatrist. What does that mean?

Loren Frank

He was a campus psychiatrist. He basically saw the students who were having troubles. As you know, that's a period in life where psychotic breaks and other things are starting to happen. He was dealing with people, onset of psychosis, depression, and other things among the student population.

Brady Huggett

He gets a job in New Mexico. Your mother meets him there at a cocktail party, but she's in New Mexico for some reason.

Loren Frank

Yes, she's flying through. I don't remember why she was flying through, but she had to spend a night there, and that was basically it.

Brady Huggett

Someone said come to this party. She meets this man. She's like, "That guy is kind of interesting. Maybe I can see him again." They switch numbers or something.

Loren Frank

Yes, exactly. One of those extraordinarily random stories.

Brady Huggett

Yes, but then it works. Is your father still alive?

Loren Frank

No, he passed away six, seven years ago now. He was 13 years older than she was, so he passed away at 92. He had also smoked for 27 years in the middle of his life. The fact that he made it to 92-

Brady Huggett

Shocking

Loren Frank

-was pretty- He was a tough individual himself.

Brady Huggett

OK. Obviously the marriage works.

Loren Frank

Yes. It worked. Not always as smoothly as one might imagine, but it definitely worked.

Brady Huggett

Yes. Meeting people at cocktail parties is still a way that does it, I guess. Yes.

Loren Frank

Occasionally.

Brady Huggett

OK. You're growing up beneath a psychiatrist father and a mother. Did she work when you were growing up?

Loren Frank

Yes. She was actually working on her Ph.D. when I was young, in infant growth and development.

Brady Huggett

Wow.

Loren Frank

I think she was doing that around the time I was 5, and then she was teaching at the University of New Mexico graduate courses, and then actually eventually went and worked at the medical school there, basically trying to teach doctors how to actually interact with patients as human beings.

Brady Huggett

Better bedside manner. That kind of thing.

Loren Frank

Yes. Then she also did some sort of family therapy, marriage counseling on the side. It was a very psychologically oriented household for better or worse. My efforts to avoid doing anything like that obviously failed utterly, but I did try for many years of my life not to do anything in that realm.

Brady Huggett

OK. That was going to be my question, is, how did you get into this line of work? It's clear that there were mentors above you or at least models that you could look at.

Loren Frank

Yes.

Brady Huggett

You didn't want it.

Loren Frank

No. I thought it was too fuzzy for me, to be honest. It was important and interesting to know how people worked, but it was always a just-so story of, "Oh, this person did this for this reason." Of course, those just-so stories are incredibly important as we navigate our own lives and try and understand people's reactions and interact with them, but I didn't find them deeply personally satisfying. I'd always known I wanted to be a scientist from, like, age 5.

Brady Huggett

You did?

Loren Frank

The things that were most exciting to me were physics. Astrophysics, cosmology, particle physics, things like what is the fundamental nature of reality?

Brady Huggett

At 5 you're pondering [crosstalk]

Loren Frank

I didn't know this- at 5 I wanted to be an astrophysicist, I said. I don't think I had a deep conceptual grasp of what that meant. Let's not overstate my intellect there.

Brady Huggett

But you—well, probably because the stars and the moon, those things are fascinating to children. It was that kind of thing.

Loren Frank

It was that kind of thing, and just how does the- I loved understanding how the world works. This is the thing. The thing that drives me professionally is just understanding how the world works.

Brady Huggett

Now it's the brain, but then it was like, "What are planets? How are things aligned?" All that kind of stuff.

Loren Frank

Exactly. Where did this all come from? This was late '70s when I was 5, 1977, and we actually knew a lot less than we do now. There were still things to figure out.

Brady Huggett

Mysteries.

Loren Frank

Yes.

Brady Huggett

There's still mysteries today.

Loren Frank

There are still mysteries. I think the granularity- some of them are very big and very far away, the mysteries. I'll say the thing that caused me not to do physics was a combination of a realization that I wasn't smart enough to be a Feynman or an Einstein. That was clear to me when I got to the early stages of college, and also the recognition that those projects tended to be huge things which were difficult for individuals to make really substantial contributions to, the things that I might do.

Brady Huggett

OK.

Loren Frank

Sorry. There's a lot between that.

Brady Huggett

OK. Meaning that, to make some huge breakthrough in that field, you would need a group of 200 people [crosstalk]

Loren Frank

Yes, or 5,000 if you're working at an accelerator, or if you look at what most physicists were working on, it was things like what are the properties of superfluid helium three, or what does this do in this context or that? It didn't feel like I would have the opportunity to do something that could be really fundamental. I didn't feel like I had the mental talent to do that in a field like physics. I didn't think I was likely to discover the theory of everything.

Brady Huggett

All right. We're going to come back to that. Anyway, you're growing up and you're looking at the stars, maybe with your parents, I don't know, but you're interested in this and you think that's what you want to do. Does that hold all the way through high school?

Loren Frank

All the way through high school, yes, I was always particularly interested in physics and related things. I read a lot of popular books on physics and so on. I ended up going to a small liberal arts college because I wanted that experience, but I chose one that had a good physics department because I thought that was where I wanted to go. Then all the way through basically most of my first year of college, I thought, "OK, I really want to do physics."

Brady Huggett

That's Carleton College.

Loren Frank

That's Carleton College.

Brady Huggett

All right. You're finishing high school. I'm assuming you did well in high school.

Loren Frank

Yes.

Brady Huggett

Did you consider things like, I don't know, Harvard, Stanford?

Loren Frank

Yes, I did. I think a couple of things in retrospect, I didn't really know coming from Albuquerque, New Mexico, where I stood in terms of abilities related to these things. I wanted someplace small where I could really get to know my professors, and I felt like that was really unlikely to happen at larger places. I didn't want to be in a lot of graduate-student-taught classes. I just wanted to be in some place sort of friendly, and I had visited a bunch of schools, and I didn't get that sense from others, like East Coast places just didn't click with me. Whereas this nice Mid- Midwestern place was a really good fit.

In retrospect, I would have given myself different advice, although I'm very happy with how it all turned out. Going to Carleton actually opened some random doors that led me to doing what I'm doing now, but statistically speaking, that perhaps was, maybe, I'm not sure it was exactly the best path for me personally.

Brady Huggett

I have to say, I had not heard of Carleton College. What's the enrollment like?

Loren Frank

Oh, it's 2,400.

Brady Huggett

Small. OK.

Loren Frank

It's small.

Brady Huggett

OK. How did you even- I guess because of the physics department.

Loren Frank

Yes. It was one of the top-rated liberal arts colleges, along with Williams and Amherst. It's just not as well known. It had a quite good physics department. I visited there; I visited Williams; I visited Amherst. I really liked the feel at Carleton.

Brady Huggett

I don't know a lot about it, but it's a town called Northfield, I think-

Loren Frank

Northfield, Minnesota.

Brady Huggett

-which is an old mill town set along a river. I could see how that would be enticing.

Loren Frank

Yes. It was more the friendliness of the people that when I visited there, I just felt like people were nice to each other.

Brady Huggett

We should say it's in Minnesota.

Loren Frank

Yes. It's in Minnesota, so there you are.

Brady Huggett

OK. These are a bunch of Minnesotans.

Loren Frank

Yes, it's somewhat more diverse than that, but it felt like a very nice place with high-quality academics and the ability for me to learn what I wanted to learn.

Brady Huggett

Accessible teachers. Good physics department.

Loren Frank

You got it.

Brady Huggett

You're all in. OK. You enroll there, still thinking, "I'm going to be a physicist."

Loren Frank

You got it.

Brady Huggett

What happens?

Loren Frank

I took classical mechanics my first year and I did fine in it. I hadn't really learned to- things had come easily up to that point, so I hadn't learned to work super hard. I ended up with an A minus, not an A, . I realized that I could do the math and solve the differential equations, but I just didn't care that much. Then I took atomic and nuclear physics my first term of my sophomore year and it was the same thing. This is all fine, but I just didn't care that much. I'd realized that the things that I'd gotten interested in in physics by that time were things related to quantum mechanics and this idea that the world is different when you look at it than when you don't.

The concept that light, for example, is best described as a wave if you're not observing it, but as soon as you put a detector in the way, it looks like a particle. This idea that there's a fundamentally different reality when you're looking at it compared to when you're not, I thought it was amazing and also elevated the observer or the observation process to a really interesting place in the universe.

Brady Huggett

It's almost like, when you think about it that way, things are more mysterious than you knew and it's worth exploring. Like that.

Loren Frank

Yes.

Brady Huggett

OK.

Loren Frank

Absolutely. That was really exciting to me. At the same time, I realized that that was not what most physics was about. Coming back to what I said earlier, I felt like I was unlikely to be studying that. That was more of a lunchtime conversation than a career. That made me realize that it was actually what- I came to the point that it was like, "Oh wait, maybe it's the observer that I actually want to understand, not the quantum mechanical parts of it."

Brady Huggett

That's different from, "I'm never going to be a genius at this."

Loren Frank

It was all of the above. It was, I didn't think I could study exactly what was most exciting to me in physics. The other stuff that was also exciting was not stuff that I was likely to really move the needle on.

Brady Huggett

Were you meeting kids at Carleton who you thought, "Well, that person actually is going to move the needle on-"

Loren Frank

No.

Brady Huggett

How did you know that you weren't going to move the needle?

Loren Frank

I think this was just a sense I had from reading biographies of Feynman and folks like that and what they were like at my age and recognizing, "OK, that's not really me. Yes, I'm smart and I'm good at thinking about things," but what I turn out to be good at and what I think I realized I was good at is more of a synthesis kind of thing rather than the extraordinary depth of comprehension in mathematics and physics realm.

Brady Huggett

OK. Then do you change your curriculum?

Loren Frank

Yes. Then I became a psychology major, which was a shock to me, honestly.

Brady Huggett

Was it a shock to your father?

Loren Frank

They were always very supportive of whatever I wanted to do. I think they might have felt quietly smug, but they never told me. It's hard for me to tell. I think they thought that was interesting and perfectly fine and so on. I was pushed towards, or I was interested in cognitive psychology, again, understanding the property of the observer. That was really a valuable experience, but that was also actually, I found, pretty dissatisfying after a year or two, because it lacked- the same problem I had with the psychology growing up is it lacked what felt to me like the rigor of being able to make mechanistic statements.

Brady Huggett

First off, I'm going to write down the term quietly smug because I love it. Meaning that the psychology part would be like, we think people act like this for these reasons without any math applied to it, without any-

Loren Frank

Exactly. Where there was math, it was very hand-wavy math. It was not predictive in any way. It was all sort of postdictive. I

think that's it; it's this idea of what science should be, what we should be striving for is something where we can say, "Hey, this is what we think is going to happen," rather than, "Oh, this is what happened. Let me make up a story about it."

Brady Huggett

Yes. OK. This is how you become a unique researcher. I don't mean you, but everyone finds their own unique thing. Yours is "I've got this physics background; now I'm going to apply that to psychology," and it gives you probably unique insights.

Loren Frank

Yes. I've also always been a programmer. The programming and the math and this idea of maybe we can write things down mathematically combined with this idea of, hey, these really interesting questions about how does this brain thing work? That turned out to be the sweet spot for me.

Brady Huggett

OK. Then by your senior year, you're a psychology major. What is your plan?

Loren Frank

There are a couple of things that happened in between that were very random and very lucky for me. The summer after my freshman year, I had applied to some summer internships and I got one at the Minnesota Supercomputer Institute. I went and I worked in Minneapolis, and I worked at the Supercomputer Institute, and I learned a lot about graphics and programming and things like that. Amusingly enough, the project we were working on was perhaps one of the first efforts to train a neural network to predict protein structure.

Brady Huggett

Oh, wow.

Loren Frank

I had no idea that this was interesting at the time. At the time I didn't even think it was interesting, but we were supposed to help with the visualization of protein structures and things like that. I learned to do a little bit of that. That led me into a second summer job the next summer, this time across the street at a place called the Army High Performance Research Computing Center, where I worked with a graduate student. She was great, and she was working on a single neuron model. She was using these really high-end machines back in the day to try and simulate a single neuron. I also helped her with the visualization. This was the beginning of a completely random exposure to neuroscience.

I stayed affiliated with them and that summer, I also did, I think a four-week summer course in neuroscience at the Itasca field station of the University of Minnesota, which is at the headwaters of the Mississippi on a lake, where I worked with people doing neuroscience experiments. We were working on turtle cerebellum and frog and things like that. Pretty random. I didn't know I was interested in this, but it turned out the combination of using these fun electronics, tools, and poking neurons and measuring things, that I was pretty good at. This is, "Oh, this is cool. I enjoy this."

Brady Huggett

I can see how this all lines up. What I'm struck by is, were you looking for these? How were you coming across these-

Loren Frank

This is why it was random. I knew at first that it would be interesting to do, that I found computing and programming interesting. Just the opportunity to work at a high-performance computing center was great.

Brady Huggett

You sought that out.

Loren Frank

I sought that out. Yes. I think that was also a lot of it. Luck, yes, but I was always looking for opportunities to do something that seemed interesting.

Brady Huggett

Amazing.

Loren Frank

The person who supervised me, a guy named George Wilcox, lovely guy at the University of Minnesota, he liked working or he liked having me around, so he helped me get the job the next summer. Then after that, this was actually one of the real benefits of Carleton, the summer after my junior year, I had applied to 10 labs around the country, based on advice from one of my psychology professors, to work, again, on a project. One of the two that was willing to hire me was at the University of Arizona, and they were interested in the hippocampus, the structure I had never heard of.

They wanted someone who could build models, computational models of this structure based on a new database they were creating of all of the different kinds of cells. They were willing to hire me. I went to Tucson for the summer after my junior year, worked on this new part of the brain that I didn't know about. That was it.

Brady Huggett

That's it.

Loren Frank

That was where I figured out exactly what I wanted to do.

Brady Huggett

OK. All right. Entering your senior year, you now know you want to look at the hippocampus.

Loren Frank

I know I want to look at the hippocampus. I went back there for- instead of spending my fourth winter in Minnesota, I instead spent that fourth winter in Tucson, because it's a lot nicer place to spend the winter. I did my senior thesis project working on this computational model of part of the hippocampus back then.

Brady Huggett

OK. I know- well, I don't know. I think I know that when you finished-- Well, first off, you won the Donald B [crosstalk]

Loren Frank

Yes. This was a prize for the- I was a co-winner of the prize for the best undergraduate thesis in psychology in the state of Minnesota.

Brady Huggett

You're making dismissive hand motions, but did that give you a sense that you're on the right track?

Loren Frank

Yes, it was interesting. Again, it's still Minnesota, right? I don't mean to diminish that. It's an amazing place.

Brady Huggett

It's not a national award.

Loren Frank

It's not a national award. It's psychology in a state. I had a hard time knowing exactly what that meant in terms of my capacity. I knew that people liked me and so on and so forth.

Brady Huggett

You've been invited back. The guy you worked with that one summer said come back, so you knew that you were contributing.

Loren Frank

Yes. I had this general sense. I think this actually might be surprising to people because I definitely came across as arrogant back then. I think I was both outwardly somewhat arrogant and inwardly unsure, because again, of this feeling that I was no Feynman or Einstein, like, "OK, how good could I be at this?" It's a weird mixture.

Brady Huggett

How do you know that people found you arrogant?

Loren Frank

Oh, well, the first time was when I got the write-up from my 7th grade shop teacher that I was a bit arrogant. I was arrogant because I had a shop at home. My dad had a lot of woodworking tools, and he taught me to use them. I was annoyed that I had to use only hand tools and couldn't use any of the electrical tools that I had been using. Apparently I was obnoxious about that.

Brady Huggett

Got it. OK.

Loren Frank

I think I was clearly a little bit cocky about some stuff. I will say, when I ended up in graduate school, things had always come fairly easily to me. That was something that killed me for a while in graduate school, because I was now trying to do something actually really, really hard.

Brady Huggett

You said earlier that you'd gone from high school to Carleton, and I get the sense that maybe in high school you just were blowing tests out of the water and you didn't maybe work that hard.

Loren Frank

Yes, it's a little complicated. I went to a really good high school, and my friends, my junior and senior year, they're really smart and I was really fortunate to be with them. Again, I didn't know how smart they were. Like, "OK, so we're doing well here, but what does that-" I didn't know what that meant in a global scheme. One of my friends went to Harvard, started his Ph.D. there, ended up going to a hedge fund. He's now a multi multi-millionaire who lives off of Central Park. I now know that those people were, yes, really very talented folks. I just didn't know that at the time. I was doing well, I worked sort of hard, but I don't think I understood what it meant to really be systematic and apply myself to things. That was something I had to learn the hard way in graduate school.

Brady Huggett

OK. You finished Carleton, and I think you're planning on going to the University of Arizona or something, right?

Loren Frank

Correct. [crosstalk] The story here is I was at the University of Arizona and the computational project was really useful. I learned a great deal from doing it, but I also learned that I had to make a lot of stuff up. Ideally, if you're building a model of something, you want to make up as few things as possible so that you're not searching for ways to make it work, parameter space searching, in such a way that you think what you- you want to find something that is going to be robust and going to be generally true and not the result of tweaking this and tweaking that to make it work exactly. I was tweaking things like mad, and it was very unsatisfying to me.

I figured, "Oh, wow, I really don't want to do that." At the same time, this laboratory, so this was specifically Bruce McNaughton and Carol Barnes. They ran a lab together at that point at the University of Arizona and an incredible postdoc named Matthew Wilson had built this system for recording large numbers of neurons from the rat hippocampus. This was the first system of its kind anywhere in the world. They had many, many more electrodes and the ability to start looking at populations of neurons, which was basically unheard of up to that time. I got to help with some of those experiments.

When I first heard those neurons, because you often run their activity through a speaker so you can hear what they're doing, I was like, "Oh my gosh, this is a structure that's involved in cognition. It's critical for memory and I can study it and I can listen to it." That was the thing that said, "OK, this is what I want to do." That lab was the only one in the world that had access to that technology at that point.

Matt Wilson was going to go off, but he was planning to work at a private neuroscience institute with no graduate students in La Jolla. I applied to graduate school there. I was accepted in February.

Brady Huggett

Arizona.

Loren Frank

Arizona. Quietly smug again, like, “Oh, good. I know what I’m doing. I know where I’m going.” Then I think it was sometime in March, I was back at Carleton, I believe, and I got an email from Matt saying, “I changed my mind. I’m going to go to either MIT or the University of Pittsburgh as a faculty member.” Do you want to come with me?

Brady Huggett

Whichever one?

Loren Frank

Whichever one. I hadn’t applied to either one. That was freaky.

Brady Huggett

How does that work? He’s going there to set up a lab and you’d be his grad student.

Loren Frank

Yes.

Brady Huggett

So you still have to apply through the school. OK.

Loren Frank

I hadn’t applied. I didn’t know how any of that was going to work. I have very strong memories of this whole process, as you might imagine, so I thought, “But I haven’t applied, what’s going to happen?” I ended up calling up the director of admissions at both places, and it was a starkly different response at the two places, to be honest. At the University of Pittsburgh, the person I talked with was a little hesitant at first, and I said, “Look, here are my GRE scores.” I had an NSF graduate fellowship at that point-

Brady Huggett

Oh, you did?

Loren Frank

-which I applied for, “Here are my grades and here’s what I’ve done.” He said, “OK, don’t worry about it. We’ll let you in.” I did the same thing at MIT, slightly different order, I think, here’s my grades, here’s my GREs, I’ve done this.” Sorry, my grades [crosstalk] NSF. Here are my GRE scores. I remember very strongly the response from the director of admissions this time, which was, “Oh, so you can speak English too.” After this experience of talking to the people at Pittsburgh and MIT, I said, “Oh, Matt, please go to Pittsburgh, because-

Brady Huggett

You’ll get in there. [crosstalk]

Loren Frank

-I’ll get in there and they seem a lot nicer.” That was still very important to me at the time. Matt doesn’t decide till June. I have ended up turning down Arizona on the deadline date, April 15th, not knowing if I’m going to go to grad school at all next year, and so I apply- Matt decides, I think it was in June. He decides to go to MIT. I apply there. Fortunately, they let me in.

Brady Huggett

Without Matt, though, the neuroscience program still exists at Arizona. Why didn’t you consider just staying there? [crosstalk]

Loren Frank

Oh, I did. Yes, it was that, Matt, I felt like was the real originator of this technology and he was also the one who had written the neural simulation framework called Genesis that I was using to do my work for the computational models. I felt like that combination in a mentor was really valuable. In retrospect, I didn’t ask all the right questions either. Again, it worked out really well and being at MIT gave me access to things that I wouldn’t have had at the University of Arizona, so that was good. Also, those years of my graduate school were the hardest, worst years of my life in many ways.

Brady Huggett

Oh, OK. Let's talk about that. I would assume that they would be- well, I wouldn't assume, but I would think they'd be hard, but why were they the worst? I'm going to ask one thing. Did you find Boston unfriendly; did you find MIT unfriendly?

Loren Frank

Yes, and yes. Here I want to be careful to not overstate my experience, but I'll try and give you the best sense that I can from what happened. I got to the lab. I actually got to MIT slightly before Matt did. We spent the first year setting up the lab. Matt had hired some other people who were fantastic. We were building things. I was learning how to use my hands for fine-motor stuff, which I hadn't really done before. That was hard for me. That first year I thought went pretty well.

Then I was trying to do what turned out to be an extremely difficult project to record from the hippocampus but also the part of the brain that gives its main input and receives its main output, the entorhinal cortex, and Matt had not done that and I had to figure it out on my own and I wasn't sufficiently systematic. I spent three years failing utterly to collect any meaningful data.

Brady Huggett

Meaning you're just tweaking things and seeing if it works.

Loren Frank

I'm tweaking things, but I'm not doing it in a super careful, systematic way. Matt was also- he was an early stage. He was also a fairly hands-off, sink-or-swim kind of guy at that point. I just kept failing, and I was miserable. I was working really hard, I was doing a bunch of other stuff, but I was not succeeding at my fundamental project to the point that the program was- because I hadn't done a requirement to write up my research work by my third year, so the program was very concerned about my progress and whether I should stay in graduate school or not.

Brady Huggett

What did you think?

Loren Frank

I was frustrated. The way I often phrase this is I didn't have the creativity to think about anything else I could do with my life. I'd always wanted to be a scientist, and I hadn't failed spectacularly at anything ever before, and I was not willing to quit.

Brady Huggett

Did you have a sense of- Did you have a crisis of confidence, yet you're like, "I'm just not going to quit. That's not in me."

Loren Frank

Yes, I definitely had a crisis of confidence. I wasn't sure I was ever going to be successful. As I told my girlfriend at the time, now my wife, I'm not sure I'll ever be happy.

Brady Huggett

In life.

Loren Frank

In life. The things that this did, that part of it I managed to- I started grinding my teeth, so I don't have canines anymore because I ground them away at night from the stress. It was really, really hard.

Brady Huggett

OK. Three years in, you're grinding your teeth, you're telling your girlfriend who will eventually be your wife, "I may never be happy," somehow she sticks with you when you say that, but you don't know if you're ever going to really make it as a scientist. How did you turn this? I know you did a postdoc after this-

Loren Frank

Yes.

Brady Huggett

-at Harvard.

Loren Frank

A couple of things happened that were great. One, and I guess I want to be fair, the lab had great resources, there were lots of really smart people here, Matt was always very kind to me, let me do things. I had an environment where I could succeed.

Brady Huggett

MIT is a phenomenal place.

Loren Frank

It is.

Brady Huggett

Yes.

Loren Frank

I think there was a lot of stuff there that I need to acknowledge. Again, the failures of my own research were a combination of my own sloppiness and not understanding what I need to do, but also being left alone to do my own thing. That may have changed in various ways by now. One thing that I did in my second year is I was still, I think- I've always been pathologically optimistic. That's another trait I have. I will get this to work eventually.

I reached out to try and find people to jointly work with on the analysis of our data; because this was the early days of having large numbers of neurons, we didn't really understand how to work with those signals, and after various not terribly successful attempts, I ended up arranging a time for us to present what we were doing to a group at the Harvard statistics department, which happened to be in the context of a class or after a class that Emery Brown, who's at Harvard and MIT now, was teaching. That was an interesting meeting, didn't really go particularly far, but I then contacted Emery afterwards and say, "Hey, would you be willing to do an independent study with me where we could maybe think about ways where we could develop new techniques for understanding this?"

Brady Huggett

Got it. OK.

Loren Frank

That was one of the best decisions I've ever made. I ended up spending three-ish hours a week or more going over to Emery's place in the North End, which happened to be where his office was because he was at Mass General Hospital, and he would teach me statistics, and we would brainstorm about ways to do things, and hopefully I taught him a little neuroscience, but that relationship and the analyses and papers that came out of that were really fundamental, I think, to keeping me in the game.

Brady Huggett

This was I think 2000 to 2003, is that right?

Loren Frank

No. No, this was 1995 that I started this.

Brady Huggett

Oh, got it. OK.

Loren Frank

The first paper I was on was 1998, which was a first-author paper by Emery Brown developing a new decoding method for understanding hippocampal activity. I would say that happened because of this connection with Emery and then that created a connection from Emery's to Matt's lab, so we developed- or Emery developed these techniques, and I followed along.

Brady Huggett

When you finish your Ph.D., then you go work-

Loren Frank

Then I went to work officially with Emery.

Brady Huggett

For three years.

Loren Frank

Yes, to do that, and also with Garrett Stanley, who was a faculty on the Harvard main campus in engineering, who was also incredibly generous to me. He basically had a room built in his lab so I could do these multi-electrode recording experiments that I wanted to do. I taught someone in his lab how to do them. Although in retrospect, there also, that I should have done a better job on as well. There I was too focused on my own path and not focused enough on making sure-

Brady Huggett

Mentoring.

Loren Frank

Mentoring or making sure that things were really working for this other person, because I think I was still worried about my own success, fundamentally, and not as focused on the broader community I was in.

Brady Huggett

I know you had those three or four years there at MIT you thought you might be leaving the- I don't know if you thought you were leaving, but you were having a rough time.

Loren Frank

Yes, I certainly thought that I was not going to succeed. That the thing I've always wanted to do in my life I was going to be a failure at.

Brady Huggett

Yes, and never be happy. Then you do this statistics and neuroscience postdoc kind of thing at Harvard and Mass Gen, and then I think you come right to UCSF and start a lab, right?

Loren Frank

Yes, that's right.

Brady Huggett

Were you an associate professor with that?

Loren Frank

No, no, assistant professor.

Brady Huggett

Oh, assistant.

Loren Frank

It's early days. Again, sort of slightly random happenstance, I got an email, I think, from someone I knew at MIT, he was a grad student at MIT, and he then was a faculty at that point at UCSF, and said, "Hey, we're doing a search now, and we think that having someone who does hippocampal stuff might be a good fit. Somebody mentioned that you might be good." I'd been collaborating with Howard Eichenbaum at Boston University and my longtime friend Josh Burke, who was a postdoc then, helping them get stuff set up for this multi-electrode stuff. Howard actually recommended me to the folks at UCSF, which was really generous of him. That story ended up with me going out there, interviewing, getting, eventually, a job offer and taking it.

Brady Huggett

Were you married by then?

Loren Frank

We were married. Yes, we were married, and this was actually another thing that did not work out the way that either me or my wife expected. She had gone from an art history undergraduate degree at Wellesley to working at MIT eventually, actually in the Tonegawa lab, and then she was able from there to get a position as a graduate student at Boston University. She was working on her project there. I had told her, "Look, I'm going to UCSF, but we'll stay here until you're done," and then we didn't. I took the job and I put off the start date for a year but that still wasn't enough for her to finish her data collection and basically do her Ph.D.

Brady Huggett

Did she mind that?

Loren Frank

Yes, it was a stressful period in our relationship. I think again, I know so much more about how to manage these things now.

Brady Huggett

Relationships you mean.

Loren Frank

Relationships and science and, like, how do we do this. We sort of decided that, like, the UCSF was just an incredibly good fit for me. I had no idea that a place like that existed at the time, and so it felt like home in a way that I hadn't felt being in Boston at all. Then again, that's my personality conjoined with what happens at UCSF. It's a really supportive, collaborative, friendly place which doesn't take itself- is not too self-congratulatory.

Brady Huggett

OK, you come out and set up your lab eventually, right? What were your plans when you set the lab up?

Loren Frank

What I had tried to do in my graduate work was to understand what was going into the hippocampus and what was coming out of the hippocampus. In my postdoctoral work, I tried to do something similar where we first developed methods to try and understand how neurons change with learning, and so here a little bit more background is helpful. The hippocampus is a brain structure critical to forming memories for the events of daily life. What's thought to happen is in the hippocampus, and maybe between the hippocampus and other areas, there's huge changes in synapses, lots of plasticity that enables this sort of one-shot learning that is the learning of everyday experience that we have every day. The implication there is that the plasticity and the way that neurons change is really fundamental to what the hippocampus does, and the hippocampus is also critical then for retrieving these memories, at least for a while after they've been stored, and that presumably is some sort of process where the hippocampus helps engage the rest of the brain. At the time, I could not have phrased any of that in a coherent way. What I knew was the hippocampus should be plastic and should evolve quickly with experience, and we didn't really know how. Working with Emery, we developed techniques for really trying to track how neural responses change on a moment-by-moment basis and then working in Garrett's lab again with his generosity I was able to do some recording experiments from the hippocampus and from other areas sort of cortical areas that might feed in or receive output that where I exposed animals to new places to try and understand how these responses evolved in a new time. Specifically, there had been this idea that the hippocampus was a very fast-changing area and the cortex was a slower-changing area, and I wanted to test that hypothesis as a postdoctoral fellow. I did all of that. The test of that hypothesis as a postdoctoral fellow didn't work out. Again, this was partially my fault because I wasn't sufficiently targeted, and I didn't think about analyzing my data in quite the right way, but I learned a lot about how the hippocampus changed, and that sort of set me up to ask, "OK, what do I need to do next to actually do this?" What I thought about doing next was the same sort of idea of we really want to trace through at every stage of this circuit. How are signals being transformed? What's special about this hippocampal circuit that would let it form new memories or do things like that? That was then, OK we need to record throughout these areas while animals are learning new things; we need to do that across different environments so that we can understand how that learning might change from one place to the other. It was still a relatively unformed set of ideas. It wasn't a crisp hypothesis about exactly how the system worked. It was, "We need to go look."

Brady Huggett

In my understanding, when you do go look and you're- this is in rats, right?

Loren Frank

Yes.

Brady Huggett

What you find is the learning is happening when the animal is not actively doing it.

Loren Frank

Yes. OK, so this is-

Brady Huggett

This is replay events.

Loren Frank

This is replay events. Yes, and I guess here what we had not been focused on replay at all early on in my career.

Brady Huggett

I can see how you end up getting there.

Loren Frank

Yes, exactly, and so what we were looking for, what one of our first papers was a let's look at what's different between novel and familiar places so that we can understand what might be learning. There we identified these sort of events that seem to be happening all the time. Lots of cells were firing together really, really strongly. That was that first hint that maybe there's this stuff. A lot of that happens sort of offline. A lot of that happens not while the animals running through a place, but it happens while the animals still at, you know, elsewhere in the place. That was sort of this first hint, and then in parallel we started looking at also these replay events more directly in particular because Tom Davidson, who at that point was a graduate student in Matt Wilson's lab, came and gave a talk in our lab and presented some really exciting preliminary results on these events. We asked him, "Hey, is it OK if we look at these in our data too?" He said, "Sure." That exciting preliminary data led us to look at these sort of replay events, and because we've been looking at multiple environments, we were able to see for example that the animal could be replaying one environment while it was paused in another environment, which is something no one else had sort of done the experiment to do.

Brady Huggett

When I saw that I was totally fascinated by that because you can realize, or at least I realized that I do that myself, like you'll be sitting in a chair doing something not particularly with your mind fully engaged, and your mind will take you someplace else really quickly and drop back, and you go, "Why does that happen?" It seemed like you had figured out why those things happen?

Loren Frank

Yes, exactly. I think there's the what versus the why. The what happens- I think we have now a good sense for that. We can see, fast-forward 20-odd years, we know what the signatures of this mental jumping are, and we can see them all the time in hippocampus. They're very frequently in the hippocampus in lots of different contexts. The why part is trickier, right? The why part is what exactly would this enable the system to do, and there we have some hypotheses which were OK, look, neurons firing closely together in time. That's a good way to induce plasticity. Maybe what this is something that's inducing plasticity either in the local network that's allowing for the storage of the memory in the hippocampus or perhaps driving plasticity downstream in the rest of the brain.

Brady Huggett

To the cortex.

Loren Frank

To cortex. That's still the idea, and ironically that still hasn't been fully tested.

Brady Huggett

This is the squishiness that you're talking about before; we think this is why we haven't been able to prove it yet.

Loren Frank

Yes.

Brady Huggett

You were able to show these neurons firing the same way in an animal's brain when it was at rest that as it had just fired when it had gone down a maze a certain way. Which is fascinating research. It brought up all these questions in my mind; one of them is the difference between sleep and awake replay. Are they exactly the same, and then if they aren't, do dreams play into that?

Loren Frank

Yes. This idea that the brain is replaying these things; what we also looked at in that paper, which you're alluding to, is what's the fidelity of this replay in different brain states? In the awake state you often get these really beautiful sequential events which look very much like time-compressed versions of the real thing.

Brady Huggett

Yes, very fast.

Loren Frank

Turns out you get lots of other events that have other complicated structures, which are also I think really interesting, where the brain might just hover in another place or something and not be a beautiful sequence, but for this part, we were really focused on the sequences. It was known before then from work, particularly from Matt Wilson's lab, that you also see these sequences during sleep, and that was also where a lot of this started, to give credit where credit is due. And what we did is then compare them and, surprisingly, the sleep sequences looked less ordered. They looked a little more free-form, so neurons that maybe shouldn't have been part of the sequence were part of the sequence or maybe the order was a little disrupted.

Brady Huggett

That's so fascinating.

Loren Frank

It's fun because you can imagine, well, look, if the brain can tweak a knob as to the sort of accuracy of a memory, you can think of it along an axis where the more accurate it is the more specific it is to one experience, but the less it lets you generalize. The more squishy it is, the more it might include related stuff, the more it might let you make connections between things that were not connected at the time. So that led us to this hypothesis that maybe this sleep stuff is actually important for something that you might more think of as insightful learning and it may be- sorry, that hypothesis may have been out there; I can't now reconstruct the order of these things, but this idea of sleep or really offline periods as insightful stuff goes way back historically, Kekule and the structure the benzene molecule and things like that. Sorry, that was clearly not our idea, but here this might be an instantiation of that where the brain regulates accuracy to change the kinds of memory storage that are going on.

Brady Huggett

You can see how, at least for me. I'll have a dream. I'll wake up in the morning, and they seem bizarre. They seem surreal, but when you begin to break them down, you'll realize that in your dream you had seen a burning house, and then you realize that while you were on a bus yesterday, you'd seen a house that had collapsed. I know that this was in rats, of course, but you begin to be able to apply to your own brain in ways that are just really intriguing to think about. I feel like this is part of the reason why that research was- the main media picked it up. It became like a, like an event for a while.

Loren Frank

Yes, I think that's right. It helps us get some understanding. I think one of the other things about it that I find really interesting, of course, we're working in rats. We don't know what they're conscious of. We don't know which of these things they're conscious of versus which are purely offline. In humans, we probably have a better ability to take stuff that might be offline and have that enter consciousness in some way or another.

Brady Huggett

Than a rat does.

Loren Frank

Than a rat does. Maybe it's a little bit squishier in humans. Indeed, there's been a huge amount of work after this point, looking at these what are called ripples, which are these high-frequency oscillations that mark the time, these replay events in humans, and finding that they really do correspond to periods of memory retrieval, both in online and more offline states. I think that's right, in some sense, that this is probably what's going on, this is probably the marker of that spontaneous retrieval, "Oh, my mind wandered, and I thought about this thing," which clearly can be potentially really useful, right? It means it lets us think about stuff, it lets us store memories by sort of replaying them, it has a lot of potential functions.

Brady Huggett

Yes, I want to ask this other question. The suggestion is that our brains will do these replay events to help consolidate memories that are more important. If I go to a busy intersection, I almost get hit by a car, we want to consolidate that memory, because next time I need to be very careful. If I have cereal for breakfast, that's not important, that happens a lot, etc. That means, that suggests that our brain has some sort of intelligence that is making these decisions. It has to be tied to some biological marker, probably, we don't know, or we do.

Loren Frank

A lot of our early work was actually trying to understand how any of that works. What we found is that new experiences, and again, other people had found data like the McNaughton lab and others that were consistent with this, new experiences greatly increase the preponderance of the prevalence of these replay events, and also rewarded experiences. We had a sense that it might even be particularly surprising rewarded experiences lead to an increase. The suggestion is that when experiences come in, they're tagged somehow based on that importance. We don't still quite know the mechanisms of that. For example, neuromodulators like dopamine almost certainly play a role, right? That if you get an unexpected reward, you maybe get a blast of this thing, it happens. That says, "OK, whatever just happened, turn it up." This becomes a knob. Then you can imagine different things occurring over different time frames might have different knobs that can sort of modulate this process.

Brady Huggett

Are you looking at that still trying to figure that out? Or somebody?

Loren Frank

Yes, I think definitely. We're not worse- we're not studying the- well, let me let me rephrase that. We're studying everything. This kind of work, I was trying to say in my lab, but we're actually doing a wonderful collaboration with my colleague, Josh Burke, and also who's at UCSF, and also Nathaniel Daw at Princeton, to look at how reward and dopamine, in particular, are related to these replay events. Us trying to ask exactly that question, does reward enhance replay? Does replay help distribute reward around the world, all of those sorts of things? Yes, we're trying to figure that out. We are, but I was thinking right now that work is going on the dopamine part is going on in Josh's lab. We're part of this group trying to figure this out.

Brady Huggett

I want to go back to this, how we started talking about media in the beginning. I think this was 2010. There's a radio show in New York called "The Brian Lehrer Show." Maybe you don't remember this, but it's a call-in radio show back when that was more of a thing when you listen to radio, and they pick a thing from the news, or maybe there's like new legislation in New York City, or the state. Then they talk about and have people call in and give their thoughts on it. They had you on very briefly. It was to talk about the replay events. Basically what we just talked about, that when the mind is at rest, it may replace something that just happened. That's the way memories are consolidated. They had you on, and they said, "Hey, Professor, we understand your work shows that you really need to take a break. You have to take a break in order for your brain to be healthy." You said, "Oh, that's not quite what we've shown. We've shown something else." They said, "OK, anyway," callers call in. They said, "Callers, how do you take a break? How do you stay unplugged?" Because that was the show that they had lined up for the day. In fact, there was a neuroscientist who called in specifically to say, "This isn't the way the brain works." Now after hearing you clarify, he's like, "I get it, what he's saying something different." Then they just went on with their "how you unplug your brain" and the *New York Times* did like a very similar thing, where they're like, "Blackberries," because Blackberry was the phone of choice back then, "Blackberries are ruining us, our brain never gets a chance to rest. It's really important. Loren Frank's work here tells you need to," -none of those things are really the work that you're doing. I'm

wondering if that's frustrating to do a really beautiful experiment, put together a paper that's articulate and careful; it's gone through peer review. It's not really, the message doesn't get clear.

Loren Frank

Yes, it's clearly frustrating. It was also real educational experience for me. I wasn't as careful in my- I tried my best to be careful on those online-

Brady Huggett

You definitely did on that radio show.

Loren Frank

Yes. I was doing my best. I had learned after some interviews beforehand. I think I'd done some interviews before that where I had been a little bit, "Yes, it could be this." And the "could be" got taken into "it is this."

Brady Huggett

You're trying to be like amiable in the interview.

Loren Frank

Yes. I think that was there was a learning experience. It is frustrating. At the same time, I feel like any public engagement with science is such a good thing that I have very mixed feelings about it. I really appreciate that people are willing to pick this stuff up. It is challenging, though, when you get to this, "Oh, this is the new cure for X," or, "This is the new thing." People don't understand the uncertainty. That our world doesn't seem to be good at maintaining the sense of what do we really know and what do we not really know. I see that as a massive problem right now, everywhere. That is one example of it.

Brady Huggett

Yes, even going back to, like, the Holocaust stuff.

Loren Frank

Absolutely.

Brady Huggett

There are things that are knowable. It's just difficult to convince people that things are knowable.

Loren Frank

Exactly. People believe what they want to believe, and maybe are not engaged as much in the process of questioning their own thoughts. I think that's a wonderful thing about really good training in science. As it says, "Look, I have to figure out how I could be wrong. I have to push that as hard as I possibly can—at least as hard as I can reasonably do so that I don't, I'm not wrong, or if I'm wrong, it's not because of something I overlooked. It's because of some mistake that I didn't understand."

Brady Huggett

If you are wrong, and someone else figures it out, great.

Loren Frank

Fantastic. Yes, actually, I tell my students that being wrong in a clear way about a prediction before we publish it, not after, is the most insightful thing that happens in science because then that framework that you've been using is not the right one. That's clear data, where positive data is never as clear.

Brady Huggett

I have one thing I want to ask you, one last thing. You said earlier that you realized that you were not going to be the world's best astrophysicist, you went on to do something else. I'm not saying that you're the world's best neuroscientist. Have you realized that this is, might be, where you should have been all along?

Loren Frank

It is. Yes, no, clearly, this is an incredibly good fit for me. It ties into me being pretty good or quite good at a whole bunch of things. Being able and knowing enough of the language of mathematics and statistics and engineering to be able to work well

with other folks who are real experts in those fields. I think that's been a lot of our strength, is sort of leveraging those kinds of collaborations. I guess the other thing I've realized is that neuroscience is becoming an increasingly social, collaborative thing. The lone investigator working with their students or postdocs in the lab is less and less moving the needle. Then it becomes, OK, not only do you have to do that, but you have to know how to interact with people, have to know how to make sure that everyone is taken care of in these collaborations so that people are not falling by the wayside. That's a whole other set of things that were typically not taught very well or may rely on a completely different set of skills.

Brady Huggett

That early physics really helped you.

Loren Frank

Yes, it's certainly a quantitative orientation. Just knowing, having the math.

Brady Huggett

Yes, the math.

Loren Frank

The math. This is what I tell students who are interested in my laboratory. If you really want to do this work, don't worry about the biology, go take the math and learn to program, because the biology you can pick up. Math is cumulative in a way that biology is much less so.

Brady Huggett

Perfect. Thank you. Thank you very much.

Loren Frank

Sure.

[transition music]

Brady Huggett

All right, that's it. I'd like to thank Loren for being on "Synaptic" and for having me into his home. I hope you enjoyed his public engagement with science as much as I did. When I left, I got a ride back down off the hill. As we worked our way toward the little town of San Anselmo, I thought, "This is the bike commute that Loren does every day. It's a pretty nice way to get to work." This episode will be archived on the transmitter.org, where we also have a transcript. This show can be found wherever you get your podcasts, Apple, Spotify, YouTube, or on whatever podcast app you use.

Some of the information for the intro was sourced from the article "Julius Caesar Arantius and the hippocampus of the human brain: History behind the discovery," published in the *Journal of Neurosurgery* in 2015. If you'd like to comment on this show, or whatever we do with *The Transmitter*, you can find us on the social media platform X—you know what I'm talking about—where our handle is @_thetransmitter. We're also on BlueSky and Mastodon. Our theme song was written and performed by Chris Collinwood. The next episode will be out May 1st. Thank you for listening to "Synaptic." Until next time.

[ending theme music]

Loren Frank

... gives her enough attention. [laughs]

Brady Huggett

She's really cute, actually.

Loren Frank

She's a really good dog. Are you a good dog? Yes, you are.

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