TRANSCRIPT [Quantum Consciousness, Microtubules & the Brain - Stuart Hameroff | 07]

Quantum Coherence in Microtubules

Let me tell you, I've been following your work with incredible interest and I think it's so transformative. And so maybe one way of starting this off for our audience is give a little background on your context and give them a sense of where you're coming from. You have this notion of the yin and the yang concept of classical, and it's a wonderful way of framing it, classical and quantum, and consciousness is on the edge. I stole that from the Kabbalah. Somebody sent me a line from the Kabbalah and said, there are two worlds, a world of strife and aggravation and a world of wonder, and consciousness dances on the edge. And I said, well, okay, the quantum and classical. So that's where I got that. It's, yeah, thank you. I'm glad you appreciate it. Well, I mean, I really want to move on that, but there's another person I've had on the, is Chris Fields, who's a- Yeah, I know Chris. Yeah, I know Chris. So that'd be interesting to see how these ideas complement or don't, but you know, I mean, Chris's notion is physics is communication across boundaries and barriers, and that there's sort of the quantum classical interaction is really a form of communication, I think is a powerful notion. Same thing we had Don Hoffman on here. I'm assuming you may know Don. So there is a new way of thinking about things that goes very deep into reframing a whole new scientific paradigm that has impact on a cultural paradigm. And so I, this is sort of the prism by which we look at it. And if you could just give a little, sort of the background and what you think is the most significant things of all your findings, and then sort of where does it, you've been doing this really 20, 25 years, right? I mean, you really- I hate to tell you how long I've been doing it. I started, I got obsessed with microtubules in medical school in 1972, so- Whoa, okay. Well, that's, that's, okay. And then, well, so let me answer your question. So I think there's several different approaches to the current paradigm that the brain is a complex computer of simple neurons. The first is that I don't think neurons are the fundamental units. They're not the analogy to bits. If you look at a neuron, it's very complex, and I hesitate to use complex because sometimes complexity is used as an explanation rather than a tool. But if you think of a single cell organism like a paramecium, it's only got one, it's one cell. It has no synapses. It's not in a network. It's a lone ranger, and it swims around, finds food, finds a mate, has sex, can learn. If you suck it into a capillary tube, it escapes faster. It finds a mate and fuses with the mate for a period of time. It is absolutely still, the only time it's absolutely still. And it's, so if that's equivalent to a neuron in the brain as a one or a zero, that's an insult to neurons. If a paramecium can do that, or an amoeba, slime amoeba can solve a traveling salesman problem, which Adam Adamatsky has shown, among others, then it's a tremendous insult to a neuron to say you're just a one or a zero, or it's just a one or a zero. On top of that, the neuron firing is the one or the zero. And I think if we look at the neuron, that consciousness is happening in the dendrites and the soma, and the firing just reports the result. So it correlates, but it's not where consciousness is. So neurons are not fundamental, I don't think. And if you look inside the neurons for what does all that cognitive stuff, like in a paramecium, it's the microtubules. Paramecium has all these cilia sticking out from, which are made of microtubules that sense the environment, that act in a coordinated fashion to swim like oars or propellers, or in the case of a flagella. And so they're sensors and they're motor effectors. They're made of microtubules, they connect to the cytoskeleton inside the paramecium, and it's the cell's nervous system. So when I was in medical school, I liked the brain-mind problem, and I thought about psychiatry, neurology, neurosurgery. But I wound up doing a research electum before my senior year in a cancer lab, just for something different. And I studied mitosis and how cells divide. And everybody else in the lab in the early 70s got obsessed with the chromosomes. This is the dawn of genetic engineering and all that. But for some reason, I got interested in how the microtubule spindles, the mitotic spindles that pull the chromosomes apart, knew where to go and what to do. They seem to have some kind of intelligence or maybe consciousness. I was interested in consciousness also back then. I'd taken a philosophy of mind class and did what we did back in the 60s, and so I was interested in the brain-mind issues. And I just said, well, how do they know what to do? They seem to be running the show at that level. And at that time, the structure of microtubules was just being discovered by X-ray crystallography by Amos and Klug in the UK. And it was a cylindrical lattice of individual proteins. And the geometry in the lattice was a Fibonacci geometry, which is a very mathematically evolved deal. And so I thought, hmm. And I was also learning about computers back then because it was the early 70s and they were new. And well, how do computers work? And I was reading about Boolean switching matrices and all this and that. And basically, you have a lattice of some sort and interaction among the... And I said, well, maybe microtubules are computers and the tubulins, the proteins, are the bits and they interact with their neighbors. And so I finished medical school. I almost took a research career offer at Penn, but instead I wanted to move out west. So I came to Tucson and did a rotating internship figuring, well, I'll figure out what to do. And I almost went into neurology, but I met the chair of anesthesiology who knew my interest and was desperate for residents. He said, well, if you want to understand consciousness, figure out how anesthesia works because we don't have a clue. And also he said, he handed me a paper that showed that anesthesia depolymerizes microtubules, although it was quite a high dose. So depolymerization is probably... But it showed that anesthesia acts on microtubules. And then he said, you know, it's a lot of fun and you'll make good money. And it's only a two-year residency at that time. I said, okay, sign me up. So I did. And his name was Burnell Brown, my chairman and mentor for years until he passed in the mid-90s. And he kind of gave me free reign to... I had to publish and anesthesia. But other than that, you know, he gave me pretty free reign. So, but I wasn't doing... I did a few lab experiments. Mostly I just did a theory and modeling in the 70s and 80s and worked with engineers and physicists, including at Los Alamos, and got to go to some of the chaos meetings and nonlinear dynamics meetings and the cellular automaton meetings because somebody invited me to give a talk in the math department about my microtubule information modeling. And I was showing how the individual tubulins interact and that you get these patterns moving. And somebody said, are you talking about a cellular automaton? And I said, what is a cellular automaton? I'd never heard it before. And they explained it. And it turns out there's a meeting at Los Alamos coming up and I sent an abstract in on microtubules as cellular, normally meaning cells as a fundamental unit. So it was a way to express information in microtubules at a deeper, denser level than in neurons. So for example, I read a book, Hans Moravec, Mind Children, maybe you heard of it. He was at Carnegie Mellon and he had this thing in there about transferring your mind to a computer. And it was based on 10 to the 11th neurons, a thousand synapses, which gives you 10 to the 16th operations per second for the brain. And then Kurzweil picked up on this number later and probably Minsky too. So 10 to the 16th, that was per second for the brain. When we get that, give us a few more billion and we'll have a conscious computer and all you rich people can download your consciousness and live forever, which is what they seem to want. But if you calculate at the microtubule level, you have about a billion tubulins per neuron and they're oscillating at various frequencies. That's a whole another story, but 10 megahertz is a good number and I'll explain why later. So 10 to the nine times 10, it gave you 10 to the 16th operations per second per neuron. So Kurzweil was saying 10 to the 16th for the brain. I was saying 10 to the 16th per neuron times 10 to the 11th, 10 to the 27th. So I was going around to AI meetings and neural net meetings being a real pain in their butts because I was saying, no, no, no, no. Your goalpost is way, way, way, way, way down, 11 orders of magnitude further down. So, and they didn't like that. They said, go away, kid, you bother us, you know, you're going to, you're going to scare off sponsors. And, uh, you know, I, I, that didn't really bother me too much. I kind of enjoyed being a thorn in their side, but one day, uh, somebody said to me, okay, Mr. Wise guy, let's say you're right. You have all this information processing. How does that explain consciousness? How does that explain feelings, love, joy, uh, all these, everything. And, uh, this is basically the heart, what Chalmers, uh, coined as the heart problem five years later at the conference I organized. But so I was having the heart problem thrown in my face five years before it had been, but other people had said the same thing. Searle had a good argument. Uh, Nagel had a good argument. Uh, you know, a lot of people talked about this issue that computation did not automatically give you

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consciousness. And, uh, this person said, uh, I was, when he asked, asked me, I was a little bit stunned. I was taken aback. I realized this. Yeah, I don't, I I'm a reductionist. I don't have a clue about consciousness, but fortunately he said, well, you should read this book by Roger Penrose called the emperor's new mind. And so I did. And, uh, it was really a, you know, a life changing event because, uh, uh, I, I didn't understand it all. It's, it's so esoteric, but also the, the way Roger writes and uses his drawings and cartoons, you know, you get, you get the idea. The first half of the book was about girdles theorem and how consciousness could not be a, uh, a computation. And, uh, he used girdle theorem says basically, um, a mathematical theorem cannot prove itself. You have to have something outside like a mathematician. And, uh, and Roger extended this to understanding, you know, just conscious understanding of anything. And this was very much like Searle's Chinese room argument. You know, the guy who can, you get the Chinese letters and you have a lookup table and you can translate, but you don't understand a bit of Chinese. And Roger's making the point that for understanding, you need something outside the system to judge for judgment. But what that was, it had to be outside the classical system. And, uh, that's where he got into quantum physics. So the second half of the book was about quantum. And I was only vaguely familiar with quantum and, uh, but, uh, again, he used a simple cartoons including, well, the first thing he did was, well, he kind of went over what is entailed by quantum mechanics, including quantum superposition. You know, there's several myths how things can be in multiple states at the same time, entanglement, how things can be connected over distance, coherence, they can condense to unitary, uh, things, entities. Uh, but superposition was, uh, he, he really, he, he's the only one who's actually ever tackled that, I think. And to do so, he went to general relativity and he said, okay, so big things like the sun curves, curves gravity. So light behind the sun can be curved and you can see it on earth. And Eddington did the experiment in 1919, proved Einstein right. Uh, Eddington got his Nobel prize and they celebrated and, uh, Roger applied it to, Roger being an expert in black holes and space-time and everything else, applied it to tiny things. He said, well, if a big, if a, a big mass has a big curvature, a tiny mass will have a tiny curvature and is essentially equivalent to the curvature. So if you have a quantum particle, that's a tiny curvature, then you can imagine that if it's in, if it's both here and here, you have a curvature here and a curvature here in space-time. And so you have a separation in space-time geometry. And so Einstein's metric, the space-time continue actually separates. And you can imagine that if each possibility continued, each space-time continued, you'd have the many worlds hypothesis. And as you know, many people think, well, they're, you know, what happens to the superpositions and they either collapse or they kind of get eroded by decoherence or there's an objective threshold or there is no collapse and each possibility goes off and forms its own universe or evolves in its own universe. So, uh, he, Roger came up with a, another category, objective reduction, where the superpositions terminate. So instead of going on and forming their own universe, the separations are unstable and will collapse at time T to one or the other. Uh, T equals H bar over E sub G, where H bar is the Planck-Dirac constant and E sub G is, uh, the gravitational self-energy, the amount of energy to pull a particle apart from itself or its space-time apart from itself. And when that reached this threshold, there would be a collapse to one or the other. And, and this was the real kicker. He said, when that happens, there was a moment of now experience, essentially consciousness, a little, little blip or bing of consciousness at a microscopic level. So it was, and I think remains the only scientific proposal for conscious experience ever put forth other than emergence, hand-waving emergence with some formula or another without saying whether it's firings or whatever, whatever it is that's, that's, that you're measuring or, or it is being processed. So, um, you know, he took it to the space-time level, the most basic level, you know, Don Hoffman may say, well, we, we have to go deeper than that. Maybe he's right, but, you know, I'll take the Planck scale for now for the basement level, worry about, uh, the amplitude of hedron or whatever, you know, where he's going. Yeah. Yeah. Yeah. Basically Roger Penrose connected consciousness to the fundamental level of the universe, which created other problems. Like how do we connect with that? But I'll come back to that. And, um, and so not only was this collapse conscious or in a micro environment where everything's random, it would be proto-conscious because this would be happening in the environment, in the air, or even in a vacuum with space-time separations and having these little moments, but they'd be random and disconnected. So they wouldn't have meaning. They wouldn't have any memory. They wouldn't have any context and they'd be happening everywhere. And, uh, you know, but that sounds, sounds weird, but proto-panpsychics say that, say pretty much the same thing, except there it's a property of matter. And then you have to explain how all those individual atoms combine the combination problem and panpsychism. But this was different. It's, uh, what, uh, Chalmers later called a pan-protopsychism or quantum pan-protopsychism. He didn't approve of it, but that's what he called it. And, uh, um, and it gave you consciousness and the choices in the collapse were not random as they are, if you make a measurement or in decoherence, uh, nor are they algorithmic as it would be in a computer, but they had this other influence that had to be the outside influence, like in Godel's theorem, which had to become from quantum. And that turned out to be an influence that wasn't random, but was what he called non-computable, which means it was influenced by what he called platonic values embedded in space-time geometry. So that was a, could you elaborate on what you mean by platonic values? And so, so there is an, an, a instantiation of platonic values in the collapse of, of, of, of, of that you're talking about. I mean, is that, is that what creates consciousness is a conscious expressing itself? It's, uh, when the collapse occurs, it's a process in the fine scale structure, the, in space-time geometry. And the way I interpreted it was that, uh, when the collapse happens, there's an influence. It's like a crooked roulette, roulette wheel. It's going to go to one rather than the other because of something intrinsic to the universe. It's going to guide it and influence it. And you could, uh, you could make, uh, make that, uh, sort of a religious thing, like the way of the Tao or divine guidance or something like, like that, or Plato's, uh, ideal forms or something like that, that guided our, our perceptions of what the world is and our actions, what to do by, you know, if you're mindful and don't act reflexively, you know, the way I think of it, you, you could be more mindful and, and do the right thing if, if, if that's how you're wired. So, um, and the, it's Roger didn't talk about the quality of the experience, but if you have that influence coming from space-time, I think it's the logical assumption is that, uh, since qualia experience has to come from somewhere, and I don't think it's an emergent complex problem because, you know, there's nothing complex about a toothache. So I don't think you need complexity for consciousness. And I think it could be very simple, but anyway, these, these, uh, or objective reduction, objective threshold quantum state reduction would, uh, would be happening all the time, but they would, like I said, they'd be disconnected. So they'd be basically proto-conscious Roger Cohen, the term proto-conscious and kind of like noise. And the way I look at it is if, if you go to the symphony and, uh, the musicians are tuning up before, uh, before they play, uh, it's kind of a company it's, it's noise. It's musicians telling me, well, they're actually tuning to the same something, but I don't understand that. So to me, it's, it's, that's analogous to proto-conscious noise. When you hear all that sound that, that doesn't sound it's discordant. And then they begin to play, uh, Brahms, Beethoven, the Beatles, whatever, and that's music. And I think that's what our brains do. And specifically what our microtubules do is they orchestrate the quantum OR events that are happening anyway. And they, and they put them together into something useful, cognitive and, and, uh, experiential. Could I just try to interpret this in a framework that not too similar to what Friston was talking about, but maybe, maybe this is a stretch, but I mean, so he was saying he he'll say to, uh, make predictions is to the reason thing is alive is it makes predictions and that, and that, and that it has a, a, it's self evidences itself and making those predictions. And, and so there's a, there's a, there's a very strong relationship between something being conscious and something being alive. And that, so when you have those interactions, you're, you're being conscious and you're being alive in the context of the observer of that kind of thing. I mean, it may be an instance of that, but it, and so when you, I mean, so when you look at sort of mitosis or something, you think it's that continuous process of preserving state and bringing it and revealing itself. And so is that, is that analogous or is that off? You said a lot there. Uh, if we go

Aromatic Rings as Quantum Objects

back to your active inference and predictive coding, which I think is, is kind of a very similar in the brain. Um, I think it's really, uh, a very good thing, uh, to describe what's happening in the brain because, uh, for example, we know that, uh, incoming, uh, uh, in from sensory information comes from the back of the brain to the front and from the front of the brain going backwards is the model of the world. The basically, yeah, yeah, yeah. So you got from, uh, front to predict, uh, uh, expectations and, and, and they come in where they don't meet where they don't match that becomes conscious. And, uh, uh, Earl Miller and his group at, uh, MIT have done some tremendous experiments the last few years on, uh, on basically predictive coding where they find that the, the, the front to back waves, well, first of all, their waves, uh, and, and their EEG ways, but there's something funny about them. I, we think they may be a phase differences at a faster scale, but I'll come back to that point. But, uh, so you, so, uh, the incoming is mediated by a gamma synchrony and the, the, uh, the feedback is, is slower and the gamma synchrony is supposedly mediated by GABA receptors. And yet, if you, if you look at the, uh, if you, if you put the subject, the monkey, basically under anesthesia, it's interesting. What, what goes away is the, the feedback from front to back and the incoming stays active, including the oddballs. If you do a test where the animal expects a, a, a, and then B unexpectedly, the B would be the oddball and, uh, the oddballs, uh, still come through. They're not, they're not, they're not affected by the anesthesia and yet there's no consciousness. So consciousness is in the front to back. It's in the predictions itself, uh, which override, uh, so, well, it can be over if you're awake, the, uh, the oddballs will, will register and you'll see something new novel and you're quite cognizant of it. But if you're under anesthesia, the oddballs keep coming through, but you're not conscious of it because the feedback goes away. So it's in the feedback that has to be the, so, but those are the same, uh, neural functions, the same receptors, the same neural activity that mediates everything else. So what's different about that? And I think that's, that's the other problem. Uh, because I think the, both the, the, the predictions and the incoming are, uh, mediated, uh, not just at the neural level, but at the deeper levels in the microtubules. If I can go back to the microtubules for a second, when Roger and I, uh, put this, put this forth in the mid nineties, we got all kinds of crap from everybody. Everybody knows the brain's too warm, wet, and noisy. How can you possibly blah, blah, blah. And, you know, you guys are crazy go away. And, uh, uh, you know, cause if you build a quantum computer in the lab, it's gotta be at absolute zero temperature to avoid decoherence. And you got, you know, you're at 37.6 degrees. You're, you're out of your minds. And, uh, you know, our, our first, uh, response was, well, you know, biology's had a couple of billion years to figure this out, so don't be so hasty. And, uh, but then actually the answer, uh, so anyway, I'll come back to that in a second, but, um, beginning in about 2010, uh, this guy, uh, who's now a good friend of mine, his name's Anurban Bandyapadhyay, he's Indian guy working in Japan and at National Institute of Material Sciences. He, he's one of these guys who as a graduate student, got a, got a position at, at NIMS, National Institute of Material Science directly to have his own lab, skipping all the postdocs. He just gave him money, do what you want. You know, you have, uh, I don't know how many years, and he did. And, you know, and so he, he built an atomic computer, uh, at him, something like that. But then he ran into our stuff and got interested in microtubules and did a bunch of studies on microtubules. He found that there are coherent oscillations in microtubules. So neurons work basically in Hertz, you know, EEG is zero to 40, 100, maybe now maybe a thousand Hertz. And he found, if you look inside neurons and you look at the level of microtubules, you'll see kilohertz, megahertz, gigahertz, and terahertz. And in fact, you see, if you, if you do the same experiment at different scales, you see, uh, resonant responses that are the same every three orders of magnitude, they repeat. And, uh, they repeat in, in, you can sort of see it in the EEG, you see it in the kilohertz, megahertz, uh, gigahertz and terahertz. And the pattern is a triplet of triplets. So it's three peaks and each peak has three peaks. And, uh, this goes, we don't know how, how fast and deep this goes. I mean, in biology, it goes to terahertz, at least maybe to petahertz, but, uh, there's some suggestion that this triple or triplets is actually in the universe and is in, um, oscillation. I mean, you see it in NMR at the atomic level, but you, but Anirban says you can, you see it even without even smaller than atoms. So there's a possibility it's, it's kind of a underlying rhythm of the universe, but we're not prepared to say that yet. But we can say that microtubules have these self-repeating, uh, patterns, resonance patterns at multiple scales, which seems to mean that they are what are called time crystals. And this was something new to me up until a few months ago, when, when Anirban started talking about it and he came out with a paper saying microtubules are time crystals. And so just from looking it up my, my own, there was a guy, Arthur Winfrey in the sixties who suggested that, that there were time crystals in biology. And, uh, but he could never prove it. And then Frank Wilczek who won a Nobel prize for, I forget the strong force or something like that. He got the idea that time crystals could be in physics. He, uh, he predicted it. And the time crystal, basically the ground state, the lowest energy state is an oscillator. So in a way it's a perpetual motion machine because you're starting with the ground state and you have an oscillator, uh, but you know, zero point energy in a biology, you're starting at KT. So there is energy there, but, uh, uh, depending on how you describe it, it's a, it's a perpetual motion machine. And I got criticized from that at a meeting by a pretty prominent guy that I fight with frequently. And I said, well, time crystals are perpetual motion machines. And I said, well, so is life. So, um, that shut him up at least temporarily. That'll do it. Yeah. So, uh, the time crystal idea, I think is one that we're, we're looking at taking very seriously because it would explain a lot. And, um, we're actually, so I'm working now in astrobiology where we're looking for the origin of life in, in molecule, organic molecules from an asteroid that my, my colleague brought back. So we're, we're going to honor bonds working on this. We're going to be doing, uh, these kinds of, uh, studies on these same molecules. And there's a hint that, uh, there's time crystal behavior, oscillators all the way down to a single individual, uh, molecules that, uh, that were found in, in a meteorite. So, uh, we haven't published that yet, but that's something we'll be actively looking at. So I think this may be a deeper problem than people realize. Could Sue, could you elaborate a little more on what you mean by a time crystal? Okay. So a, um, a crystal like salt or quartz is atoms that repeat periodically in space. So you have a crystal spatial crystal time crystal, you have a dynamical system with has a resonant dynamical pattern. And that repeats over time, basically not just periodically in time, but at different frequencies, different scales. So you have the same behavior in kilohertz megahertz gigahertz and terahertz. Basically, you know, the, the faster ones are buried in the, in the slower ones. And I asked Anirban how he discovered this, uh, this time crystal behavior. And he said, well, I was looking at the, uh, at the kilohertz and, uh, and then I, uh, I, I noticed off to the right on the graph, there's a little tiny little bit of noise. So I blocked out the killer, uh, the kilohertz and then blew up the next phase, which was megahertz. And I saw the exact same pattern. And when I did that, I saw off to the side, a little, a little note would look like noise. And I blew that up. And that was also the same triple of triple. So it's, it's repeating at every three orders of man, about three orders of magnitude, every, every three orders. So that gives you a, a scale and variant hierarchy, kind of like a, it's a time fractal basically. And, uh, go and, you know, one of the problems in biology, and I don't know if in AI, uh, too, probably it should be is how do you transcend scale? In other words, you know, we're, you know, the size we are, elephants are bigger and then we have little tiny things. And yet within us, we have all these tiny things going on and, and yet, you know, we're one entity and so forth. And the time crystal is, is the way to transcend scale, I think, because you have the same information or maybe consciousness repeating, uh, at all scales from the terahertz and petahertz down at the, like the angstrom level to, uh, hertz at our level and everything in between, but regular periodically. So it's the same information. Whoa. But that that's, that's, I think looking at some of the, some of the work that Michael Levin's doing, he's sort of getting at the same thing, I do believe. And what he's talking about, um, and, and, and it's, yeah, well, he's, he's studying electric fields. That's right. And, uh, he doesn't, he usually doesn't describe their frequency. Oh, that's right. That's right. That's right. And nor does he describe where they come from. I mean, people in neuroscience are talking more and more about ephaptic fields as opposed to, you know, axonal firings and synaptic transmissions, basically electric electromagnetic fields, uh, interaction. But, um, the problem with that is electric fields tail off, uh, I forget by the distance rapidly. So you'd have to boost them at periodically to get from one side of the brain to the other. And by the way, in gamma synchrony, uh, 40 Hertz, you have perfect zero phase like synchrony across the brain, which is pretty much impossible to explain by neural transmission because of the delays and so forth. And if it's not neural transmission, and if it's not effective, it has to be quantum entanglement, uh, to have zero phase like synchrony across the brain. So, wow. Wow. So I, and I think, so I think, uh, I think

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neuroscientists need, uh, need quantum without, uh, entanglement without realizing it. Another example is, is cognitive, is spatial temporal binding. So if you go back to sensory processing, you know, vision, uh, V1, and then it moves forward. Um, you get shape, color, motion, meaning, uh, of an object at different places and at different times. And yet you don't see something shaped, then it's colored, then it's motion, then it's meaning, ah, it's, it's an airplane or it's a bird or it's a kite. You see, ah, it's a kite. It's a yellow kite fluttering in the wind. You see it all at the same time instantaneously. And, uh, uh, entanglement occurs not only spatially connecting things over space, but also over time, which, which is all very important for other reasons. So I think, uh, even mainstream neuroscience, although they won't admit it, need entanglement. This zero phase lag, uh, gamma synchrony thing, if you look, well, nobody understands it, so we ignore it. And that's the problem. They ignore these important things that, that should be looked at. So I think, uh, uh, quantum is, is necessary for, for neuroscience for a lot of reasons, including consciousness and binding. I think Chris Fields would make that point too, but, but, uh, but I, I think that you're, you're, you're, you're speaking to specific kind of mechanisms and microtubules as a way of explaining this and, and, and the, the different, the, the, the, the, the fractal, uh, is the continuity at different scales. And then if you have this time crystal phenomenon, that's, that's, that's sort of fundamental, right? I mean, that's the case, right? I mean, it's not, it's, it's, it's a property of the universe. Right. Well, then the question is, uh, uh, you know, so how does this happen in the warm, wet, noisy brain? So let's go back to decoherence because, uh, the answer is hinted at by anesthesia, I think. So, um, uh, as I mentioned, one of the reasons I went in anesthesia was to figure out consciousness and the anesthetic gases, um, they were discovered in the 19th century, uh, initially as, as party, uh, party favors because people, you know, they would sniff ether and have ether frolics or sniff nitrous oxide, laughing gas. And if they breathe too much of it, they become unconscious. And somebody said, you know, if they, and if they kept them breathing, they'd wake up fine and they didn't vomit and aspirate that sort of thing. But, but generally, you know, you'd go to sleep and you wake up. So somebody realized, well, Hey, we could use this for surgery in 1846 at mass general. They did for the first time and with ether. So if you look at the anesthetics, so there, there's roughly a dozen, uh, gases that can be used as anesthetics and they all have different potencies. And these two guys at the turn of the 20th century, Meyer and Overton tried to figure out, you know, where they were acting in the brain, what they were doing. And so, uh, each, each anesthetic has a potency compared to the other anesthetics. And that potency applies to all animals. So at equilibrium, it would takes the same concentration of a particular gas. Let's say halothane to put a flea, a worm, an insect, or a whale, or I don't know about a whale, but yeah, well too, if you could get it, but anyway, large animals, small animals, they all have the same potency at equilibrium. It may take a while to get to equilibrium, but in the gas phase, but once you're at equilibrium, it's the same amount to put you to sleep or a flea or an elephant. And, uh, that's, that tells me the consciousness is the same in all animals and plants. Plants also respond to them and they have, you know, they follow the sun and all that, and that stops with anesthesia. And that's also mediated by microtubules, by the way, in the, in the, where the root meets the stem, apparently. So, um, yeah, plants have, plants have microtubules too. So, um, each one has a potency that potency holds for all animals. They want to know, well, where's it acting? So they, they tested their solubility. So in anesthesia or medicine or pharmacology, you give a drug, you want to know where it goes and where it goes depends on its solubility. And there's, you know, there's, uh, 17 solubility compartments that pharmacologists worry about, and you can boil it down to two big ones, oil and water. And as you know, oil and water don't mix. And then there's all these gradations, but just consider oil. So, uh, oil would be like the aromatic rings, uh, in proteins, for example, or fats or membranes, but it turns out where anesthesia acts is in proteins. And so when a protein folds, you have these, uh, the aromatic amino acids with the rings like benzene or indole and indole is in, um, you know, serotonin and all the psychedelics and, uh, the hexagonal dopamine. So all the, all the molecules with, um, uh, feelings and consciousness related. So they're non-polar. Okay. They're oil-like and they don't like water. So in a, in a protein, the aromatic rings coalesce and they get the water, they get rid of the water. So there's no water. So the thing about warm, too warm, wet and noisy. So forget about the wet, because in this, in this, uh, oil-like reason, there's no water and there are, and these molecules are optically active. So quantum optically active, they're all, they're fluorescent. So if you hit them with UV, they peter along and then they give off another photon, lower energy. And when that petering along, that's actually jumping from different quantum states. And, uh, and then they emit. So the quantum, quantum optically active, there's no, and so they avoid the water. So what about the warm and noisy part? What I just described would work for like one little, one little, uh, protein with, uh, aromatic rings. But, um, if you then take that and make a polymer out of it, so it's a periodic lattice, this goes to something that, uh, Schrodinger first said in 1935 in his book, uh, what is life where he, he said that, um, uh, we need, there needs to be a periodic or aperiodic lattice. Aperiodic means not perfectly regularly. You want a little, uh, something off and that could process information and, and, and, uh, be a quantum device. And he said that life needs that. And I think that was probably before DNA was discovered. And then, uh, in the sixties and seventies, a guy named Herbert Froelich, whom I had the fortune of meeting was a really interesting guy. He was a, a, uh, quantum by, uh, quantum, uh, superconducting expert. And he looked at biology and, uh, he said that, uh, if you have a polymer, a lattice, like Schrodinger had said, where each of the, uh, each of the components had a non-polar region where you can have inducible dipoles. So he didn't want permanent dipoles oscillating because that's charged. And that that's, that causes decoherence, but if you have an aromatic ring, so it goes, it goes to benzene. So let me go back to, uh, or the base of organic chemistry. Like when I was a pre-med, they said, well, if you want to go to medical school, you got to ace organic chemistry. Difficult, you know? So, um, and it's all about, uh, the aromatic ring. You start with benzene, where you have six, six carbons. They have three extra electrons. So they form these electron clouds above and below the carbon, uh, the carbon ring. And that electron cloud is basically a space filling volume of super quantum superposition because the electrons are everywhere. It's like a quantum object and, uh, it doesn't do chemical bonds. It doesn't make chemical bonds. Um, but the only bond, the only, well, the carbons can make chemical bonds, but the electron cloud itself only does quantum interaction. So if you take, for example, two benzenes, you know, if you put it in bulk form, it's, it's gasoline. It goes to your car. You know, cool. But if let's, and if you put it in a planar sheet like graphene, you have interesting quantum properties, or if you put in a cylinder, like a fullerene and a tube or a buckyball, you also get very interesting quantum quantum properties. So, um, if, if you have two of them, if let's just say two, two, two benzene rings, they will attract each other because the electrons in one will repel the electrons in the other. So you get a dipole over here and, uh, and a dipole here. So you have two dipoles and they couple and they oscillate back and forth. And so two, two benzene rings, but left by themselves would just, um, attract to the van der Waals radius and start rocking and rolling back and forth. That's probably the basis of life right there. Um, you need at least two of them. So, um, but then if, if you have a nexus of those as in a, in a, in one component of a polymer in a periodic lattice, they're gonna have long range interaction in a couple and you have, you have quantum coherence over the whole thing. And that's what Froelich said. Froelich said that you're gonna, you're gonna have these giant dipoles and the whole system can be a quantum system. In the microtubule, the, uh, the, the lattices, uh, they go up, but they also go around in spirals in, in three different spirals in the Fibonacci. So you have these interesting, I call them topological qubits, uh, quantum bits that follow the pathway in the microtubule. And, uh, again, it's all in the aromatic rings and the whole, the whole thing is, is oscillating kind of like a laser. In fact, it's a lot like a laser where, you know, a laser is a quantum device at warm tempera

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the quantum, the stuff in the quantum areas, uh, because that, that's where the anesthetics bind. They bind by the same quantum forces and they, they're attracted, you know, they get out of the, they get out of the blood and water cause they're too polar and they go right to fat and membranes and inside proteins. We have these aromatic rings, so they're attracted to the, uh, to the, the quantum areas and, and that's the pharmacology of anesthesia. Well, it has a particular, uh, Hildebrand solubility coefficient of 15.1 or something, but that just tells you it's, it's non-polar aromatic rings, kind of like benzene. And, uh, and that's where consciousness happens. Well, and, and in micro, but you need a proper vesicle or vehicle. And I think that's the microtubules. So when, when, so this is a, a major departure from, from, um, the more

Gaining Scientific Acceptance

traditional computational model, to say the least. Um, and why, what is it? I've heard that. Well, what is it? So I, I, and, and you're getting more and more evidence from a variety of fields. I mean, you're getting rid of the empirical evidence to this. And, and, and, and, and, and to me, it just seems to be make, and I'm not, I don't have a layman on this, but it just seems to make sense. But what is it? And this is where I'm sort of interested in the, in the sort of history of science. What, what does it take for something that radical in order to get acceptance, even when there, when there's evidence that's coming out? I mean, does it, do you have to create a warm temperature quantum computer or something on these principles? I mean, what, well, that's a very good question. Um, and in fact, Anirban is doing exactly that. He is building a, a, a growing, a warm temperature, organic quantum computer in India. And, uh, so, he's going to talk about that at our conference. You know, we organize this, the science of consciousness conference, which will be in Barcelona in July. I'll say, I'll send you, uh, information. I'd love to go. I'd love to go. I mean, this is great stuff. I mean, this is, yeah, yeah, yeah. But getting back to, you know, how is this accepted? Uh, not very well by others because a lot of people are invested in their, uh, in their, uh, you know, neuroscience, the brain is a computer AI and, uh, what's happened in the last few years, I think, well, I can put it in, uh, in terms like this. So we started, started this conference in 1994. There's been a, a kind of a divergence of opinions, uh, in, in two general areas. I mean, there's a lot of different areas, but, but two basic areas. Uh, one is the brain is a complex computer of simple neurons where each neuron firing is a one or a zero. And the brain is a computer and no different from AI. And therefore AI should be conscious and AI people love this. And I think they're, they're pouring money into labs that do this kind of work. And those labs are sucking up to AI and they don't want to hear from us because we're going to ruin the gravy train. So, uh, and the other side are people, uh, who think that consciousness is fundamental and somehow connected to the, to the universe in one way or another. And this includes, you know, spiritual people like Deepak Chopra or, or a lot of people like that Eastern Eastern philosophy people. And, but there's also a lot of physicists like Roger and, uh, who would, you know, doesn't like to talk about spiritual stuff at all, but also, you know, people like Nassim Harriman and, and, uh, and many, many other people who think there's a fundamental connection. They're trying to make the connection. So, um, uh, you know, I, and I'm in that, in that camp, but, uh, so my, so on the one hand you have the brain is a complex computer of simple neurons and the other, uh, the consciousness fundamental. And I call my term is the quantum orchestra. I said, the brain is not a computer. It's a quantum orchestra because you have these, uh, frequencies, spatial temporal frequencies. So if you get the brain, you go into the neuron,

The Quantum Orchestra

which is roughly Hertz. Then you go to, you know, kilohertz, megahertz, gigahertz, terahertz down and down. And eventually, although this, this part's going to be hard to prove, you can get to the plank scale. The time crystals could go all the way, all the way down time crystal behavior, even without the biology, it could be in space time. Uh, Nassim Harriman thinks that, and some other people think that, uh, Honorbron thinks that, but, but, uh, you know, uh, I'm just worried about now in the biological sense where we can go down at least to terahertz and see these oscillations. And actually the terahertz is where anesthesia acts. Anesthesia blocks the terahertz oscillations in the proteins, in the aromatic rings.

Wheeler’s Concept of Participatory Physics

And that slows down everything else. The classical stuff continues, but things that depend on the quantum, uh, stop. But if it's an orchestra, then who's the conductor? Ah, that's a good question. It's, it's more of a jazz, it's more of a improv or jam session. It's a very good question, but, um, there doesn't need to be an orchestra. There doesn't need to be. That's what I meant to conduct. I mean, there's, there's, yeah, they conduct. Yeah. Yeah. You don't need somebody doing that because it's more, you know, in a jam session or improv or, or jazz, you know, there's no, there's no conduct. But they're synchronizing among themselves. I mean, they. Yeah. They're resonating among them. Exactly. Yeah. Yeah. And they're tangling and resonating among themselves. So that would argue for a plurality. I mean, how does that tie into John Archibald Wheeler's concept of physics is participation of multiple observing. Is that, is that consonant with that perspective then? Yeah. Well, you know, uh, the interpretation of the measurement problem include the, uh, the conscious observer where if you observe, you know, the consciousness causes collapse of the wave function. And Dave Chalmers espouses that view for some reason. We're good friends, but we're, we're, we're feuding right now because he went over to the, uh, you know, he came up with a hard problem and talked for his whole, ever since I've known him for the last 20, 30 years that, you know, consciousness is a really difficult problem, you know? So this all started at our first conference in 1994, where the first morning I had two philosophers who were, uh, three philosophers. The first two were very famous. And at that time, philosophers read from their papers with no eye contact, no slides. And he introduced me to the audience. They're all falling asleep, you know? And I said, oh crap, this is going to suck. And then, uh, Dave had lot was an unknown at that time, uh, uh, postdoc and had lobbied me for a, a plenary talk. And I, and I needed another place. Okay, fine. So he gave the third talk and fortunately, uh, I'm glad I, anyway, he gave a fantastic talk. He got up there and said, you know, we have all these easy, these problems like memory, attention, behavior, reportability, and they're difficult and people spend their lives on them, but they're relatively easy compared to the hard problem of why we have feelings, qualia, you know, the term for experience and so forth. And, uh, you know, he had this kind of rock star, uh, uh, or about, um, long hair and he pranced up and down and, uh, he really rocked the place. I have to say it was great. And at the coffee break, I'm going around listening like a playwright on Broadway and I'm going, Oh, the hard problem, the hard problem. So they really got it. That really galvanized the meeting, the whole movement really for, but then, uh, he kind of went over to the, especially the last few years where AI has been coming on strong. He said, well, I didn't really mean that. I think AI will be conscious. So despite all the LLMs, I'm, I still don't think it will be, but it's politically and economically wise to do that if you're in the field, because the AI is pouring money into it. If it's purely computational, but I mean, I mean, so there is the work, I mean, uh, Chris Fields and Don Hoffman and others have done a sort of how to create conscious agents as a sort of formal basis. And can you have a, some kind of an agent is interacting with a, a quantum field in order to actually assert its own sense of itself. I mean, would that be, I mean, is it, I mean, you're not reducing it to a computational model. You're, you're, you're actually just creating the conditions by which consciousness can, can emerge through those interactions or that communication between the classical and the, the quantum. I think for agency or for causal action, you need collapse. That's what I'm getting at. But yeah, yeah, yeah. Yeah. I mean, a field, a field per se, won't do it. I mean, these ideas of consciousness of the field. Okay. I mean, that's where the, the agency emerges in the consciousness of the interaction between the two, the collapse of the, and the, and the, is there something exchanged between the classical and the quantum? I mean, is there, there's information that's being created, patterns that are being created. I mean, is there, I mean, I, I, one of the things I, I think I guess I'll, I mean, Chris will talk about a hologram writing to it, but and there's also the Susskind's notion of a sort of his, his old concept of second law of quantum complexity. I mean, where you have, seems to be a principle that's driving this kind of interaction between the two. Yeah. I don't, I don't like, you know, some of my best friends espouse complexity, but it's, it's a circuit complexity. It's a concept of circuit. I mean, I know complexity gets overused. I mean, you know, I mean, but it's like an answer when it's not really a solution to anything. Well, what he's saying is that each state tries to understand every as a representation of every other state and in a sense. So that, that, that drives the whole process. So that'd be part of the interaction between the two. I'm just throwing these ideas out. Well, I'll go back to Roger's idea because I think the collapse is key. And, you know, over the years, a lot of people have said, Hey, you don't, you know, because they don't like objective reduction. They don't like quantum gravity. And, uh, and that, and that, and they may, they don't like physics and a lot of neuroscientists. So they'll say, you know, the micro two, that's a great idea. Why don't you forget about that quantum stuff or forget about quantum gravity and just say, you know, it's quantum coherence, this and that. And I'm thinking, uh, you know, and you'd have a good, good thing going. You don't need Penrose. And I'm thinking, wait a second. He's got the only, the only theory ever what consciousness actually is. And he's Nobel laureate and he's freaking brilliant in every aspect that I've ever heard him talk about it. So I'm not gonna, you know, leave him. And he tells me, yeah, people say, yeah, you know, uh, quantum gravity, you don't need microtubules. And he said, well, the best thing I know. So we stuck with each other and, uh, I I'm, I'm for, I'm glad I'm both on both sides, but I think you need collapse for, for consciousness. And you know, prior to collapse, it's all quantum superposition, collapse, objective reduction, then you get classical states that creates the classical world. That's what I mean. That's what I'm trying to say. That's what I was trying to say. Okay. Yes. At least for a moment, then it happens again and again, but you create a reality and that happens with any collapse, including the ones in our, in our brains. So, so when you see, I mean, what kinds of changes in, in, in the fee in your field or what kind of evidence do you think will move ahead this way of thinking? I mean, I, we go back, I mean, we looked like, you know, whereas behaviorism was dominant. I mean, there were, there were all these and, and, and, and Chomsky wrote, you know, the take of Skinner and that sort of killed it. Is it, is it, but how would this proceed? What, what, what kind of thing needs to be done to, to, to have this new, this new notion of consciousness and, and, and. Yeah. Well, we've come a long way, actually. I'm pretty sure we are. And however, well, a couple of things are happening. Number one, despite the, despite the giant suck up to AI and the part of neuroscience, I think there's less and less evidence that the classical neuroscience can explain consciousness. But you know, that's, that could be, well, that's your opinion. So but I think, I think the real the proof should come from anesthesia because we know anesthesia is selective for blocking consciousness, sparing everything else. So if we knew exactly what anesthesia does and where it does, what it does, where, what it does it to, whatever it is, that would be a big step forward. So when I, you know, as much of a fan of microtubules as I, as I am and was, and as an anesthesiologist studying anesthetic action, going back to the seventies, back then it was all membrane. Well, first it was, is it the lipids? Okay. It's in the proteins. Okay. Which protein? So they spent, uh, in 1984, it was shown that anesthetics act on proteins and everybody said, okay, which membrane protein, which receptor, which ion channel is it? The sodium channel is that the GABA receptors that this is that. So they spent 25 years studying membrane proteins and anesthetics bind to a lot of them. GABA receptors, they bind quite, quite avidly. And, uh, and also serotonin receptors, glycine, um, acetylcholine, others. After 25 years, the leading people in the anesthesia researcher research, uh, wrote a paper led by a guy named Ted Eager, who was the undisputed King of anesthetic mechanism research. They wrote a paper in a prominent anesthesia journal saying, okay, there's no single protein or no combination, no single membrane protein or a combination of membrane proteins that can account for anesthesia because, because of the Meyer Overton correlation, that indicated a unitary site of action that they're all acting at the same one. And, uh, not all anesthetics bind to all to GABA receptors, for example. So that, that kind of rolled that out, nor, nor anyone. And so you'd have to show a Meyer Overton correlation for an effect on a particular protein. So, uh, anyway, in 2008, after 25 years of, of looking for membrane protein sites of action, Eager et al. Published this paper that said, we need a new paradigm. This ain't working. I, I knew Eager, he tried to recruit me to go to UCSF actually. And I, I always wonder whether staying in, I, I love Tucson. I didn't want to go to anyway. So I knew him, let's put it that way. And I wrote, and I said, Hey, microtubules, because there's evidence in anesthesia backs, you know, find some microtubules. And they totally ignored me. They just went on, they went to, uh, oh, back to lipids and emergence and all this other stuff. But then, uh, we started getting, uh, evidence for anesthesia acting on microtubules. So for example, there was just a recent study that, that came out, well, first of all, a lab at Penn, Rod Eckenhoff's lab at Penn took us after this, uh, you know, uh, after they kind of said memory proteins, won't do it. They did a systematic review of binding and they found, for example, that anesthesia, uh, bind 70 different proteins in a cell in a neuron, about half in the membrane and half in the cytoplasm. And to figure out which ones are just, you know, side effects or inconsequential and which are the mechanisms they did, uh, they looked at gene expression and supposedly the gene expression changes if it's a functional effect. And they found the gene expression in, in the tubulin, in the microtubules. So that, that pointed to microtubules, uh, although they didn't want, they didn't even pick up the banner. They just, they didn't want to go there because they were getting ridiculed by, for even suggesting that. Um, and then they did an optogenetics experiment where they had an, uh, an anesthetic, a fluorescent anesthetic that, uh, it was an anthracene molecule that was anesthetic only when you hit it with UV light and it fluoresced. And, uh, they gave that to tadpoles who had transparent heads. And, uh, when they turn on the U they're swimming around, they turn on the UV and they go belly up. So they're under anesthesia. And when they ground them up, they found that they, it was bound to microtubules. And they also did a clinical study where, um, people on taxol, uh, mostly women because taxol is an anti-cancer drug for breast cancer, which stabilizes microtubules. So the microtubules can't depolymerize to go to, for mitosis. So it blocks mitosis, but it stabilizes the microtubules. And they found that people on taxol needed more anesthesia that it was that the stabilization or maybe just blocking the access of the anesthetic to the binding site. So that was another example of, uh, for, um, anesthesia act on microtubules. So fairly recently, a group, a neuroscience group at Wellesley college, a small school with a young, uh, professor of neuroscience with a couple of students and a bunch of rats, anesthetized the rats. So they put them in a chamber with and turn on 4%, I think it was isoflurane and then clock how long it takes for the rats to fall over, you know? So it's a very simple experiment, but it's the kind of thing that Meyer and Overton did, you know, uh, 150, 125 years ago. And, uh, so they, uh, they gave the rats a drug called apothelone D, which is a microtubule stabilizer, like, like the taxol. And they found that when they did that, the, the animals needed to, uh, significantly longer exposure to go to sleep. So the apothelone D, which was stabilized in microtubules, uh, antagonize the anesthetic. So, uh, I mean, that's a very simple study, but it's pretty profound. Actually, there's been nothing, absolutely nothing like that for any other protein, any other receptor. So even though it's, it's kind of a, a simple study with a few students and a few rats, it's a fantastic study. And, uh, that guy would be, I invited him to speak at the conference in Barcelona. Yeah. But in the meantime, you know, my, my friends and colleagues, they get, they're going the other way. They don't want, they've given up on Meyer Overton. They just want to talk about emergence and stuff like that, which has nothing to do with anything. So I think, but I think, uh, okay. Uh, what's going to change it. So I can't say too much about this because I promised honor about it, but I'll, I'll tell you what I think I can say. And that is that, uh, I, I told, I said on about, we got it. We got to see, uh, we got to, so honor bonds discovered these, uh, you know, uh, kilohertz megahertz gigahertz, terahertz inside neurons. And you can now, measure from the scalp buried in the EG. And he calls it the DDG, the dodecanagram for 12 orders of magnitude. And the most robust signal from the scalp is megahertz. And you get a peak at about 10 megahertz. And, uh, he's published a couple of studies. He's, he's, uh, uh, finishing up and writing up a big study he did in India. He went to a hospital in India and got the whole hospital to help him in the operating room, uh, measuring this megahertz as patients go under anesthesia, as patients are in the ICU, their coma, and as they die and versus awake. And, uh, I promised him I wouldn't divulge the results, but I'm very happy about the results. Let's just put it that way. And within a few months, uh, this paper will, uh, be out or we can, we can talk about it, but, uh, let's just say that there's that, uh, it's looking like anesthesia acts at this faster level and it slows everything down. So that's gonna, that's gonna change a lot. I think I, there'll be some pushback and, and, but you know, uh, that's science. I mean, so I, I'm pretty, I'm pretty, uh, pretty optimistic that, that within a couple of years, we're going to be on top of things. Oh, really? Well, I mean, the Templeton foundation did a number of studies too on this and then they, and they, it was a certain confirmation as well, I think. Templeton. Yeah. They had this program, the, uh, accelerating research and consciousness. Right. And, uh, and they put it, they gave a lot of money and, uh, they, they wanted, uh, uh, adversarial collaborations. Yeah. And this is something that, uh, Kavanaugh and Canham, the guy won a Nobel prize, came up with these adversarial, uh, collaborations. And the idea is that you have proponents of one theory and then proponents of the other theory, and they meet and they come up with an experiment that will falsify one or the other. Right. Right. And, uh, I was worried about that right from the start. We, we had a meeting with the people from IIT, Integrated Information Theory. So Tony and, uh, we couldn't come to an agreement. Um, they wanted to, uh, they wanted us, so we said, well, we wanted to do is, is have a, uh, have microtubules and detect quantum effects. And we've said, we'll be able to detect clear quantum effects, quantum optical effects in microtubules, and then we'll add anesthesia and see if it goes away with anesthesia. So that was our proposal. And they said, no, no, you got to do it in a live animal, in an attacked animal. And what I had just described doing this in, uh, a microtubule would, would be done in a quantum optical bench, you know, zero vibrations, uh, all these things lined up. You've probably seen optical benches, lasers and stuff, and you get the sample. And, uh, so, uh, because you can't have, uh, vibrations from the table or from cars or anything. So, um, that's what we proposed. And then, uh, Kristof and Julio said, no, it's got to be done in a live animal. So let's do that experiment in a monkey and we'll put the monkey to sleep. And I'm going, well, we can't do it in a monkey because we've never even done it on a bench in a single microtubule. Well, that doesn't, what does that tell you? Well, it tells you more than what you got. So we get, anyway, to make a long story short, we didn't, we couldn't come up with a common experiment. I don't think their theory is, is even falsifiable. I don't think it's a real theory. I think it's bullshit. And I like those guys, but, but anyway, um, Templeton gave us money just to do our experiment. So the joint experiments with monkeys or with humans, they're, they're, they're cost them 5 million each and all of those. And they did a couple of them. So IIT versus global neural workspace. And they, and it was all, uh, in, in, inconclusive, all this money just down the drain, they gave us, uh, 200,000 to do two experiments, one of which is completed. And the other one, I don't know, they're still farting around with it, but, um, they, uh, what we showed was, uh, and we went to Princeton, we went to a neutral lab, actually Greg's goals lab, it was pretty skeptical. And, uh, but my, my colleague, Jack Jaczynski, uh, sent had a postdoc who wanted to go to Princeton. So we went to Princeton, worked in schools lab. So it wasn't something we cooked up in our lab, but where we could, you know, put the thumb on the scale, it was, it was done in, um, in a skeptics lab. And, uh, we were able to show room temperature quantum effects in a microtubule where, and what we did was, uh, well, uh, what they did, but I helped design it, but they, so you have a microtubule and you hit it with a UV and then you, uh, you label it. And so when, when you get a flora, a fluorescence effect, but not just in one protein, it actually propagates along the microtubule. So I think six, uh, six tubulin lengths and this, and which was farther than you can account for by classical. So this, this propagation had to be a quantum effect. So we proved that. And then we had, we had two different anesthetics, a gas anesthetic and a soluble anesthetic, and both of them inhibited, uh, dampen the, the, uh, the quantum effect in a microtubule. So we called our shot. We, we made our prediction. We did the experiment and we proved it. And we published it in a good journal, but because it wasn't the big adversarial collaboration, it didn't get a lot of publicity. And in fact, what did get all the publicity was the, the, the failed experiment between the IIT and GNW and Christoph and Dave, my two former buddies had this, they had made a bet 25 years ago, whether they'd find the neural core of the conscious now. And they made a big stink about this at the ASSC meeting and didn't even mention the fact that yes, one experiment worked. They just talked about the experiments didn't work. So we got totally eclipsed, but that's good. ASSC is totally towards the classical material computational, and we've now gravitated more towards the, the quantum fundamental level. So, um, you know, uh, and they're fueled by AI money and we're, we're just on our own. But I think with the anesthesia experiments with, with Anirban's EEG experiments, if you're measuring megahertz, it can't come from membranes. It has to come from microtubules. Like I said, between that and the more anesthesia experiments and, and some other stuff. And I think, I think I'm pretty confident actually that in a couple of years, uh, we'll be in good shape. Maybe sooner. I mean, you can grow a quantum computer in room temperature. I mean, do you think that's an avenue that, that, that will, that's something you can see in five years or so? I mean, I think, yeah, sufficient qubits to do interesting computation. We'll see. But I think Anirban says it's already working in principle. And, uh, you know, compared to building a, uh, you know, cold quantum computer, it's pretty cheap. I mean, it's, it's a million. That's what I mean. Yeah. So if you can grow your own quantum, grow quantum computers, you need to interface. So you need all these peripheral devices. So he's already making a supply chain, uh, anticipating demand in the future. He's a pretty smart guy. So, um, uh, I think, I think that's going to be really good. And, and other people are getting into that now too. And, uh, but, uh, you know, he was deferred as usual. And I heard Peter Diamandis, you know, him, I mean, and then the XPRIZE guy, and he was expressing a wish for it. He said, the next big thing is going to be room temperature quantum computers. Well, I was doing it at, at a place called, uh, IIT Mandi, you know, India has these, uh, 25 of these IIT, Indian Institute of Technology. And the newest one is in Mandi, M-A-N-D-I, which is up in the Himalayas. And, uh, I first went there about three years ago. Uh, they, they got into some of our work and they invited me and I've been there a couple of times and they said, uh, you know, where do you think we should go? I said, you should go talk to Honorban. And they, they knew of them, but he's kind of aloof and kind of hard to, uh, get a hold of, get a hold of. And they, they weren't really sure. I said, uh, please just talk to him. So while I was there, we had a Zoom with him and he was saying what he was doing. They got interested and he eventually visited. And, uh, to make a long story short, they went to the Indian government and got money to build an organic quantum computer in Mandi. And that's what they're doing. And the Indian government is taking this very seriously because they see it as a way of leapfrogging the West, you know, forget about the, the cold con, we're going to no, no, I, I, I agree. Are they the only ones doing that? I mean, that's surprising is that, I mean, there's not other people's are doing, but I think other people are doing it now, but they were the first, I'm pretty sure. I'm not sure exactly, but I've, I think other people are catching on too. Fantastic. Fantastic. Well, I mean, just, just in a, in a sort of a wrap up on sort of the, the implications, I mean, so this is a very different way of considering reality.

Space-Time Geometry

It opens up a very sort of different kinds of cultural forms. And if you take the full implications of this, I mean, do you have any thoughts or comments on that? I mean, you know, because if you start to extrapolate, I mean, it's, it's, it really upends a lot of conventional thinking is certainly reductionist thinking and, and the primacy of a space, the primacy of space time in a classical world is being the only explanation of things say, no, no, no. Maybe that's, this is a, it's only part of the, you know, the yin and the yang and the, and there is this interaction at the edge. I mean, would you extrapolate that? Yeah. Well, it reflects on, on you know, our place in the universe and the nature of reality and, and you know, who and what we are and why we're here, you know, we are a process in space-time geometry. So it's kind of like neutral monism, but where it goes to quantum and collapse goes to quantum classical, but it also brings up another issue. So I retired from anesthesiology six months ago, I'm now working in astrobiology and we're looking for the origin of life. And the way I got into that is that because Rogers objective reduction can happen in anything for proto-consciousness, including space-time, even without matter, but, but in certain kinds of molecules and organic molecules in particular, I was thinking about the origin of life and evolution. Cause I've never been, I've never been real happy with, with certain aspects of evolution. Like for example, life started and then I don't know how many millions or billions of years before there were genes. So if there's evolution, it's, it's without genes and, and how and why would these molecules start behaving in such a way to be purposeful and to, to survive? Why would they want to survive or care about surviving? If there were any feelings, it doesn't make any sense. It never made any sense to me. So I thought, well, could it be the feelings were there from the start that, and the only, the only way to get to that was Penrose OR because most people say consciousness is a complexity. So, you know, the brain started doing, you know, he started doing all this complex information processing. You got to get consciousness. Well, and some people say, well, that's fairly recently with, you know, language and tools. But, you know, that didn't make any sense to me. If you, you know, you look at an organ, a worm, it's doing, it's, it's doing stuff because why do we do anything? Because it feels good. Right. Even, even us, you know, okay, we delay our gratification. We go to school, we get a job, blah, blah, blah. But still, it's all what makes us happy. Right. And so I thought, well, that would have been a good instigator for the origin of life. So I wrote this paper. I was, I was asked to write a chapter for a book on human nature. And so I wrote, I wrote this paper, the quantum origin of life, how the brain evolved to feel good. I put it out there. It's a chapter. So, you know, it's just, I figured, well, it's out there. Nobody, nobody seemed to notice at the time. About two years ago when I'm thinking, okay, what am I going to do when I'm done with anesthesia? Because I want to keep doing, so I was just going to keep doing research and consciousness and so forth and so on. So I heard from a guy, a planetary scientist at my university of Arizona, Dante Loretta, who was in charge of a 20 year NASA mission to an asteroid to bring back organic molecules. Well, the flight was seven years. It was 20 years in the planning. And he was actually young when it started. He was the assistant to the, to the head guy who got sick and passed away, unfortunately. And at a fairly young age, Dante became the acting chief and ran this NASA project. So when he contacted me about two years ago, they had landed on the asteroid. Well, they don't actually land. They kind of scoop, scoop it up because if they land, they go right through it. It's just a bunch of rocks and they come out the other side, maybe. But they had successfully, and showed me the videos. Amazing what they did actually. It's, it's actually a simulation of the video because they didn't have a camera. Anyway, they brought, they had this, uh, or they, they knew they picked this asteroid because it was very dark, which tells them it's carbon. And, uh, it was also a possibly on a collision course with the earth. Which gave them another reason, you know, for defense, you know, for NASA. Took, uh, three years to get there. They actually circled it for a year to survey where to land and measure it and all this and that. And then one fateful day, they basically had one shot. They went down and they scooped it up. They got the lid closed and they headed back to earth. So they knew they had something. And, uh, this had only been done twice before by Japanese on a different, uh, asteroid, Ryugu. And they got two grams of organic material and Dante's project said, we hope to get 60 grams and they got 120 grams. So there was a big, it was a big success, but they still don't know exactly what they had. And then, uh, last September, the thing came down in Utah and it was on NASA TV. Dante went up there. I could see him, uh, you know, go into the thing and he has a great picture of him looking at this thing. It just came back from this asteroid. So, so, well, before that, so he, uh, he contacted me about two years ago. He said, I, you know, he said who he was and he said, he read my paper, the quantum origin of life. You want to talk to me about it? He said, you know, he was, he promised NASA that they would find something related to the origin of life. So while the thing's coming back, he had to figure out, well, what the hell am I going to, what are we going to do now? You know? So, uh, he said, you know, he liked, he had the, he had independently thought, well, maybe consciousness was there first. And he went to the literature and the only paper he could find on this was mine. He told me, and he said, I'd like to meet with you. And not only was it mine, I was at the same university. So he, you know, across the street at the medical school. So I said, well, yeah, I'd be happy to talk to you. So I went over and he told me the whole story. I was kind of blown away by it. He showed me this video and he said, uh, do you want to work on this? I said, hell yeah, I do. In fact, I'm retiring from anesthesia. I'd be happy to work on this afterwards. So, and I figured, you know, I, I have a pension, I would just work on it, but he, we actually got funded and, uh, from a private source that had been funding my work and, uh, he's been giving us money. So, um, I'm actually getting paid for it. And I brought an honor bond because he can do studies on these molecules that nobody else can do. And for example, uh, now that we have the samples, you can see that, uh, one of the, the key finding in the samples are what's called nano globules. So in the, uh, the origin of life story and the primordial soup, the supposedly we had these, uh, they had these micelles, operin micelles, that were kind of like, uh, liposomes, you know, with, uh, uh, a shell and then something inside, which included organic molecules, uh, aromatic rings, which could have the fluorescence in the quantum. So I, in my paper, I said, well, maybe they got together and started having Penrose OR and having, uh, uh, conscious or proto-conscious moments, some of which would be pleasurable and they would arrange themselves to optimize the pleasure. And, uh, so that's what I proposed in this and that life started to optimize pleasure or to avoid displeasure. And that was the basic idea. And, uh, and I explained how it could happen with, uh, with, uh, OR. I talked to Roger about any, and Roger said, well, I don't know if you can get that many. And so he was, oh, he was skeptical, but, you know, typical Rogers, well, you know, go for it. So, uh, so I did, and I wrote the paper and then Dante picked up on it and he had a similar idea, but didn't have a mechanism cause he wasn't familiar with, uh, Penrose OR. And so, uh, so we wrote a position. So a guy gave us funding for a year. He said, write a position paper on what you're going to talk about. And we did, and we published it in a, um, actually a, uh, uh, kind of a popular piece for, uh, IAI TV. Uh, I'll be happy to send it to you. But in the meantime, anyway, that was good enough for the guy to give us a million bucks to keep going. And, uh, so that's what we're doing now, right now. So what I'm working on now, which I'll get back to, uh, later today and over the weekend is, um, a paper for a, uh, uh, meanwhile, uh, I'll get back there, but Dante's been writing papers like crazy from all this material they got. So this is only one small facet of the whole thing. They, he said, I don't know, six nature papers on this, uh, something like that, but, um, the paper I'm writing, well, we're all writing it, but I'm, I'm the lead on it is, uh, the, the, the consciousness first proposal for the origin of life. And so we're going to take the pop piece that we wrote and beef it up scientifically. And, and hopefully we'll have some, uh, some results. We already have some results showing like oscillators at the ground state in, in molecules. So even before we got the venue samples, we had, uh, there was a, there was a meteorite that came down in, in 69 in Australia. And, uh, there's one molecule that, uh, that they found, which was this branching tr

The Origins of Life Through Astrobiology

the intelligence system of a protein, just the aromatic rings. And then we found that we found the, uh, the time crystal behavior at the, at the most basic level. So, um, we, we, we did a poster on that, but we haven't, we haven't published that, but we're going to continue with that. We're going to do the same thing with the molecules from Bennu. And, uh, you know, tubulin, you know, in evolution is kind of a, a strange story because, you know, the, uh, the origin of life, uh, you know, uh, the controversy about, uh, uh, intelligent design, you know, which usually is meant to imply God comes in and puts his finger on life, but, um, it could be a bottom up intelligence or consciousness first, actually. That's kind of what I think tubulin has never fit in the evolution because, uh, intelligent design people have used it as example. Why would you, why would a protein evolve to make a giant structure that you don't know about in advance or it doesn't know about it? It's kind of like, why would a brick evolve to build a skyscraper? And so there's always, and now we're seeing that, well, maybe this, this came from a lot earlier than before. So we have, we have a lot of possibilities. Maybe it is just a pleasure seeking molecule or something like that. Or, or maybe it's, uh, you know, uh, the, uh, the fuller fullerenes. So organic hydrocarbons, I, I was telling you about, you know, so the aromatic rings in, in aromatic, uh, pro amino acids and everything else, organic molecules, stars, young stars put out aromatic rings. I mean, all the aromatic rings came from asteroids, which came from stars. And by the way, it looks like Bennu that, that, uh, we're studying, uh, the asteroid that Dante picked actually was formed by a larger thing hitting a planet that, or something that had primordial soup on it, because we have everything in the Bennu to make life everything. Uh, all I've got a list somewhere, but everything you need to make life is in this one, uh, asteroid, including these, uh, these, uh, uh, nanoglobules, which are fluorescent inside. So we're, we're trying to honor bonds, trying to probe them without breaking them. And he's actually, so he's doing non-invasive, uh, studies using cloaking and tunneling and all this and that. So, uh, hopefully we'll have some answers and then we're going to, and if we get, so we've defined, uh, so you could say, okay, you guys are looking for the origin of life. How would you know if you found it? You know, what are you looking for at the molecular level that would tell you it's alive? Because most explanations are functional, you know, like adaptation, homeostasis, this and that. Well, you're not going to see that at that level. So we've identified the, uh, what we call primitive signs of life or signs of life include,

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including like the, uh, the, um, time crystal, uh, ground state oscillator, coherent oscillation between aromatic rings, uh, you know, and we've got actually, uh, 10 of them. I forgot the others. So that's what we're going to be looking for on these molecules. We wanted to put out what we're looking for first. So if we find them, we could say, Hey, we predicted this rather than after the fact saying, yeah, this is what we want. So we're going to publish that in this paper. And, uh, well, it's already out in the poster, but we're going to publish and the other, the pop piece, but this will be, this is in for the, uh, astrobiology journal. So I guess it's a whole special issue on theories of origin of life. So we'll be up against all the others. So that's what I'm going to do. That's a worthy task. That is a worthy undertaking. And, and, and, and to know that you, you, you've answered it would be that that would be unequivocally, uh, prove that. Yeah, no, that's fabulous. Well, I really appreciate you taking the time here and this is a really, really informative, uh, journey and a lot to digest to say, thank you. And thanks for absorbing it. I think, uh, you know, you, you picked up on it and I appreciate that. And, uh, well, I mean, I just think it's very transformative and it's just interesting to me from a, from a history of science, what does it take for these ideas to overcome resistance within other groups? You know, I think I'm in the note, I say max boxes, you know, science progresses one, one funeral. So what does it, the social construction that doesn't allow the recognition of it, how do you move beyond that anyway? So this, this is great stuff. And thank you very much. Well, thank you. It was a pleasure to talk to you. Okay. All right. Take care. Thank you. Bye-bye.