MARY LOU JEPSEN INTERVIEW PART ONE - INTRO

Hello Ars Technica readers. My name is Rob Reid, and this is a serialization of an episode of my podcast - which is called the After On podcast. We're splitting this one into 30-ish minute chunks that we'll post today and tomorrow, roughly at lunchtime. East Coast time zone, that is. Which the magic of the Internet can allow you to timeshift into any lunch hour you like. Worldwide! This week, our guest is a holographer, a one-time academic, a former CTO of Oculus, and a present-day entrepreneur named Mary Lou Jepsen.

As you may know from previous posts here on Ars, my show dives deep into complex issues in science, tech and society which we should all probably understand a bit better. Each episode's built around an in-depth interview with a world-class expert in the relevant field**.** I do 20-30 hours of up-front research and preparation before sitting down with my guests. And I structure my interviews carefully, so that their information density hopefully feels a bit more like TED talk than a meandering long-form interview.

So - on to the detailed background on Mary Lou Jepsen.

Rob Reid: With over 200 patents to her name as well as four organizations that she either founded or co-founded, Mary Lou is both a technologist and an entrepreneur of the highest order, and along with her startups, her career has included stints in the top echelons of engineering at Intel, Google, and Facebook. If it delivers on its maximum promise, her latest startup, which is called Openwater, could completely reorder two very different domains, medical imaging and telepathy. Yes, you heard that right.

Rob Reid: Now, I can't guarantee that Mary Lou's products will ultimately enable telepathy, but I will guarantee that there's nothing remotely outlandish about her approach or ideas. In fact, two of the smartest people I know have given that highest endorsement of investing in her company. Mary Lou's personal story is both harrowing and inspiring. The science behind her technology just fascinates me, and toward the end of her interview, we have a conversation about ways to perhaps revolutionize healthcare delivery in the developing world that I haven't stopped thinking about since we sat down. And now, on to my interview with Mary Lou Jepsen.

THE INTERVIEW BEGINS

Rob Reid: What a beautiful morning to be in your gorgeous living room, and for those who can't see us, which is everybody, could you just briefly describe your home and your neighborhood, because it is so fabulous and unique?

Mary Lou Jepsen: I live on the houseboats in Sausalito that were really a hippie colony where people squatted in the '60s, where they didn't need to pay any rent, and it's

really evolved into this really great way to live. It's earthquake proof, because when the ground liquefies, big deal, we're already liquid, and there's this big secret about the Bay Area: There's a bay.

Rob Reid: There is a bay, and you see it, you're surrounded by it.

Mary Lou Jepsen: You're surrounded by it, and we've got a couple seals on that platform and you'll see pelicans come in and kayakers.

Rob Reid: How many houseboats are in here?

Mary Lou Jepsen: There's about 450 houseboats, and when I bought my first houseboat, they were considered landfill. It turns out that more professionals moved on the boats. I think Stewart Brand, for example, is a neighbor. He's been here since 1975.

Rob Reid: Cool.

Mary Lou Jepsen: And as a result, somehow, we were able to become legal in 2004, so all of a sudden, houseboat prices went up, and now we've gone from landfill to they're thinking of historic preservation of them.

Rob Reid: So talking about your company and your work, I feel like most new idea in technology could logically occur to anyone of a number of people who have the necessary background to conceive of the idea at the time when it first becomes possible, but occasionally, something comes along that could really only arise in one brain because of the exotic intersection of knowledge that the idea requires of inputs, and I view your current work through this lens, because I see it as arising from four background elements, which you probably uniquely possess.

Rob Reid: They are, first of all, a deep expertise in holography, which very few people have; an equal depth in the 2D graphical world of screens, of all kinds of screens, which more people have, but relatively few holographists have; thirdly, years of pushing billions of dollars' worth of product through the trillion-dollar manufacturing infrastructure in Asia; and then finally, a very personal and highly relevant history with brain tumors, and in the Venn diagram of backgrounds, you may be the only person who occupies that very spot. And so if you wouldn't mind, I'd like to go through those very, very briefly, perhaps starting chronologically with holography. You, I know, grew up on a farm in my own tiny state of Connecticut.

Mary Lou Jepsen: Yes.

Rob Reid: And then went to Brown University in the even tinier state of Rhode Island, and shortly after you got there, you discovered holography.

Mary Lou Jepsen: Well, I'd been fascinated by it, but there was a class in it. It was amazing. It combined all this really hard math problem and really beautiful lasers and a lab, a whole room that was like a camera that had to be completely dark and a table that floated on air. You'd set up these mirrors, and there was these magnetic bases that you locked down. Nothing could move more than a hundredth of the width of a human hair when you made this setup to make your hologram come out right.

Rob Reid: That's cool. You stayed with that for years, right? That became the focus of your graduate work, didn't it?

Mary Lou Jepsen: Yeah. My parents said they'd help me pay for college if I'd major in electrical engineering, and they were quite serious, but to maintain any ounce of creativity I might've had, I started to take art classes. I joined a punk rock band and needed to express in different ways.

Rob Reid: And so you stayed with holography. Were you still working with holography when you went into your PhD stage?

Mary Lou Jepsen: Yes.

Rob Reid: You were.

Mary Lou Jepsen: I was doing liquid crystal filled holograms, did them for windows, for day lighting, and then also for the new burgeoning area of microdisplays, which ended up being my first startup with two other grad students. Oh, I was also working on crazy things, like projecting video on the moon. The side art projects keep me happy.

Rob Reid: Wait, wait, wait. Let's take a little bit of a side detour here. Projecting video on the moon? Did you do that, or was that a concept?

Mary Lou Jepsen: We didn't do it. I designed a system to do it. I had been making these really big installation holograms in primarily Australia, on the Great Barrier Reef, and Germany, and they filled a city block or a beach cove.

Rob Reid: So it was like installation art that you were doing on a grand scale?

Mary Lou Jepsen: On a grand scale, but they only worked when the moon was in the correct position or the sun was in the correct position, for maybe 10 minutes a day for 55 days a year, for example. So figuring all of that out, I had to write my little moon package, and then I thought, well, why not just go for it, just project right on the moon? Could you do it? So I figured out how to do it and raised some money and got a lot of support, actually, from musicians and MTV, rock stars and so forth.

Rob Reid: How do you do it? Or how would you have done it?

Mary Lou Jepsen: The only way to get enough light that I could figure out is when the sun, Earth, and moon were all in the right positions, using the heliostatic mirrors. Those are these big 3 x 3 meter mirrors that track the sun. They basically reflect the sun to a tower that has water in it to boil the water to make steam to drive a turbine to make electricity. They went in during the Carter administration-

Rob Reid: Really?

Mary Lou Jepsen: ... with solar funding. Yeah, there's one in Daggett, California, near Death Valley. It's a square mile of mirrors, and looking at that and adding a couple million dollars of optics to the top, it's enough light where you can project the light on the moon and see it with the naked human eye.

Rob Reid: And you would do this when it was a new moon so there wasn't any light on it?

Mary Lou Jepsen: Right, a sliver moon where it's actually dark, and so-

Rob Reid: That is cool. That's still a cool idea.

Mary Lou Jepsen: Yeah. You can do it. Actually, Bill Gross has this big solar array, so every time I see him, I'm like, "We should do that at some time." But here's the thing, I got these death threats and people were really offended by the idea and the question is, just because you can do it, should you do it? You know?

Rob Reid: Yeah.

Mary Lou Jepsen: And so also I was getting sick at the time, but really, I think it was the death threats, and you had to do it at a sliver moon, which had religious significance-

Rob Reid: Oh, right, in Islam.

Mary Lou Jepsen: ... in Islam.

Rob Reid: Yeah, and people might've been afraid you were going to put the Coke logo up there or something like that, which, by the way, Coke would've been delighted with, I'm sure.

Mary Lou Jepsen: I had meetings with both Coke and Pepsi, and they were both vying for who was going to sponsor this thing.

Rob Reid: There you go, okay. And then you did get sick. It was almost a year, right, and it was mysterious, wasn't it?

Mary Lou Jepsen: I'd been on and off sick since about age 12 with long bouts in the hospital, two, three months at a time for unknown diseases, and I had been getting progressively worse for a few years. It's insidious, though. It's so slow you don't even notice. You just ... You know, I was late 20s, I thought I was getting old, so

yeah. So then I was sleeping 20 hours a day, living in a wheelchair, body covered with all kinds of different color sores, and I couldn't move half my face, so I drooled. The worst part was, I could no longer subtract in my head, and so I didn't think I deserved a PhD in device physics-

Rob Reid: Wow.

Mary Lou Jepsen: ... so I dropped out of my PhD program to go home to die, because nobody could figure out what I had. I mean, I was at an Ivy League school that had a med school. I got access to a lot of the professors. They tried to debug what I had, but they could not figure it out.

Rob Reid: And then what ended up happening?

Mary Lou Jepsen: One of those professors actually sprung for the cost of an MRI, and then it turned out I had a brain tumor, which everyone else was depressed about, but I was thrilled, because I had a diagnosis and like, great, there's a solution for that, cut it out. And so that worked. I had brain surgery and it took about 30 days to get the appointment, have the surgery, recover from the surgery, and then I got back into grad school.

Rob Reid: Now, I want to echo something you just said. You were in an Ivy League school, you were in the wealthiest country in the world. It was a while ago, but at that point, MRI technology was already pretty widespread, and I think a lot of Americans, particularly more privileged ones, incorrectly think of MRI as being a pretty broadly accessible service, but it certainly is not, as evidenced by your own experience. It saved your life. Had you not had this generous professor, you probably would have died. Could we talk briefly about the cost and the inaccessibility of MRI, even in wealthy countries in 2018?

Mary Lou Jepsen: Sure. We have about 50 MRI machines per million people in the U.S. today, but you get to Mexico, you've got two MRI machines per a million people. I was talking to a reporter in the U.K. who was just in the hospital for five days, and she said she only needed to be in there for two days, but it took three days to get a slot on the MRI machine in the National Health Service in the U.K. These things are expensive. They're a few million dollars. They're the most expensive room in hospitals. It's a two-ton magnet with liquid helium cooling it at all times and shielding, and it's about half a million to a million dollars a year of maintenance for these machines.

Rob Reid: These are like 26, 27,000 a scan.

Mary Lou Jepsen: They're a profit center for hospitals, so they want to do more of them now, today, 2018, and it generated $50 billion of revenue in the U.S. alone last year.

Rob Reid: Even in this very wealthy country and even for people who have fabulous insurance, an MRI is a better way to diagnose breast cancer than mammography, but it is rarely used because it is so expensive.

Mary Lou Jepsen: Yes. Mammography is not as good a diagnostic as MRI. MRI's too expensive. It's not used for first line screening in this country or in any country in the world because of its expense.

Rob Reid: And if it were, presumably a certain number of lives would be saved, but it's simply too expensive even here to use it?

Mary Lou Jepsen: Yeah, it's about 10 times better in terms of diagnostics than mammography.

Rob Reid: Wow. So now I'd like to fast forward through your post-tumor, pre-Openwater career, because that's when your expertise in 2D screens, which I think is very important, and also your experience with this massive manufacturing infrastructure in Asia, came into play. So after recovering, you started a couple of companies, right?

Mary Lou Jepsen: Yes. I started MicroDisplay, and we worked on virtual reality systems and projection displays and wristwatch video and early smartphones, and basically we were putting liquid crystals on silicon chips for very high resolution screens.

Rob Reid: And also in the midst of that, you co-founded One Laptop per Child, correct?

Mary Lou Jepsen: Yes. I did two screen startups, although I moved to Intel and was the CTO of their display division, convinced them to close it and decided to give up any kind of commercial stuff forever, and went to MIT and became a professor.

Rob Reid: At the Media Lab, right?

Mary Lou Jepsen: At the Media Lab. So I became a professor at the media lab, that's what I was going to do with the rest of my life, and it took like three weeks to start One Laptop per Child with Nicholas Negroponte, the founder of the MIT Media Lab.

Rob Reid: Could you give us a brief sketch of what One Laptop per Child was?

Mary Lou Jepsen: So the idea was to get one laptop to each child, everywhere.

Rob Reid: Throughout the world, but particularly the developing world

Mary Lou Jepsen: Particularly the developing world, yes.

Rob Reid: What year was it that you guys-

Mary Lou Jepsen: It started in 2005.

Rob Reid: Yeah, when laptops were not at all widespread in the developing world, nor even necessarily in the industrialized world.

Mary Lou Jepsen: People thought it was a joke. Craig Barrett, the then-CEO of Intel, my former boss's boss's boss, and Michael Dowling and Bill Gates and Steve Jobs just thought it was joke, it would never work, publicly and privately derided us. It seems so crazy, because laptops at that time were about $2000, plus all the software you put on them. Think of a loaded laptop and what that cost. Nicholas was really going out and selling it. I was the chief technology officer, and nobody actually asked me, but I'd never shipped a laptop before, but I shipped a lot of the most expensive components in a laptop before, the screens and the way you drive the screens, which is really 70% of the cost, and so I had an idea of how to do it and did it, but really, the issue was, more than cost, was power, because half of the children in the world live without steady, ready access to electricity. So we figured out how to make a one-watt laptop and shipped it. A lot of that was the screen architecture that I invented that was sunlight readable and retina display before Apple coined the term.

Rob Reid: Long before Apple, yeah.

Mary Lou Jepsen: In the lowest cost laptop ever made, and super low power.

Rob Reid: Now, the organization did not ultimately itself hand a laptop to each child in the world, but there are a lot of things that came out of it that were radically important. You also did ship a lot. How do you encapsulate the legacy of One Laptop per Child?

Mary Lou Jepsen: Right, so that's true. We delivered to ministries of education and only did a billion dollars of revenue. We catalyzed the $30 billion of revenue and catalyzed the fastest growing consumer electronic category ever recorded, the netbook, which was a low-cost small laptop. But the legacy is really changing the equation of what a minister of education can do for the children of their country in the developing world specifically.

Rob Reid: Now, after OLPC, you went through a couple of the very storied companies of the digital world. You worked first at Google and then at Facebook, correct?

Mary Lou Jepsen: Yes.

Rob Reid: At Google, you were working on moonshot projects with Sergey, correct?

Mary Lou Jepsen: Yes.

Rob Reid: And in context of what was then Google X, what constituted a moonshot and is there anything that you worked on that you can actually mention? Or is that still deep, dark secret?

Mary Lou Jepsen: I can talk about the patents, because if you just Google my name and Google in patents, you can find out what I was working on. A moonshot basically was what Larry and Sergey thought was cool. I think that was the best definition of a moonshot.

Rob Reid: That's a good definition.

Mary Lou Jepsen: Something that they thought was cool enough to put some resource on and explore. And so The Wall Street Journal reported that there was this sort of LEGO TV system that Google was working on and reported that I was involved in it, and if you look at my patents, you can see a way to make screen-like walls, where there's no line between it or bezel or anything.

Rob Reid: There's no seam. You could put up one screen, then another screen, then another screen, and slowly, steadily, as your budget allows or as your design sense allows, cover more and more of your wall with screens. I'm just guessing. Is that roughly-

Mary Lou Jepsen: Yeah, see it really changed TV, but you also change your digital life. Because LCDs right now cost $15 a square foot.

Rob Reid: Wow.

Mary Lou Jepsen: It's amazing. It's cheaper than walls. So everybody can have a million dollar view or a shared wall, if your family lives in a different time zone or a different geographic location, it can just be this ambient thing. You can change decoration. We have all these photos, millions or at least hundreds of thousands at this point, for lots of us, but basically changing screens to enable ambient screens and wall-like screens. It must be noted that Google does make a lot of money advertising and there's profound implications for large screens and walls. So I figured out how to do that using really low cost, high volume manufacturing processes to make that quickly.

Rob Reid: Very cool, and then Facebook. What was it that took you over to Facebook from Google?

Mary Lou Jepsen: Something happened that I really didn't like that is somebody else's story. Somebody I was working closely with was treated very badly by the organization. Mark Zuckerberg had wanted to have dinner, and so I'm like, "Okay, let's go." I felt very well cared for and Sergey was very supportive of my work and I liked working with him and he's so bright and creative. And then Mark handed me this folder at dinner. It basically added a zero to my compensation package, 10x kind of thing. So then I just realized I was worth a lot more to Facebook at that time, because Mark had bought this company called Oculus for $2 billion, and really, really great computer gamer people like John Carmack, they were working on VR and I'd built VR systems in the '90s in VR 1.0, but here's the thing, is they didn't have any experience shipping any kind

of consumer electronics before, and particularly distinguished by the screen and the optics, and that's really the thing that I was really specialized in, so they thought that I would be really valuable.

Rob Reid: And you were there for how long?

Mary Lou Jepsen: A year and a half. Oh, can I say something more about Oculus?

Rob Reid: Absolutely.

Mary Lou Jepsen: So the cool patents there are sunglasses VR, AR with a toggle. Everybody says, "Is it VR or AR?" and the answer is, "Yes," and RR, real reality, and so you need glasses that can do it all. And so if you look at my patents, you'll see, sunglasses, no excuse, that form factor that does VR or AR. And also the AR, if you've got aliens and you're playing a game or you want a person to appear on the couch over there in my living room, don't you want the person to be opaque?

Rob Reid: Right.

Mary Lou Jepsen: Not translucent?

Rob Reid: Yeah.

Mary Lou Jepsen: So we have what they call in computer graphics alpha channel, so that is what I was doing at Facebook and Oculus, primarily.

Rob Reid: How many patents is your name on?

Mary Lou Jepsen: I don't know. I haven't checked recently. I had to check about a year ago, and I had more than 200.

Rob Reid: Wow. So let's talk about near-infrared light, what it is and why it matters so much to the work that you're now doing.

Mary Lou Jepsen: Near-infrared light, silicon is sensitive to it, and your body's translucent to it, but it scatters it.

Rob Reid: So as we all did in summer camp, you put a flashlight up to your palm and you look on the other side and there's this creepy red glow. It's not transparent like our bodies are transparent to x-rays, but some gets through.

Mary Lou Jepsen: Some gets through, and you see red light, and infrared light is more red than red light. It's actually a little bit longer wavelength. We can't see it with our eyes, but if you put on night vision goggles, you can see it.

Rob Reid: Yeah, it's the nearest neighbor to the light that we can see, but it's lower energy than the light which we can see, which means it's absolutely noncarcinogenic. It doesn't cause cancer at all, et cetera. It's not something we're afraid of.

Mary Lou Jepsen: Right. It's benign and we're talking about light levels lower than you would experience outside on a sunny day.

Rob Reid: As I understand it, if you pulse a light source, an infrared light source on, let's say, one side of your hand, because we used that example, have a detector on the other side. Some tiny fraction of the light rays will go right through. A lot less than 1%, but some tiny fraction of lucky rays will get right through, and I love the term, it's called the ballistic rays, did I get that right?

Mary Lou Jepsen: Yeah. That's right.

Rob Reid: But the overwhelming majority will be scattered in some way on their journey through the hand. They'll bump into a bone or they'll be bumped off course, defracted in some way-

Mary Lou Jepsen: Just by your flesh, right.

Rob Reid: Just by your flesh.

Mary Lou Jepsen: Because it's microscopic, right. It sees it as it's bouncing around like billiard balls on a table, if you will.

Rob Reid: It's kind of tunneling its way through, but some goes right, right through. And this is the thing that is self-evident to you because you've been working in the field for so long, but it simply blows my mind. We humans can make detectors that are so sensitive that a detector on the far side can tell the difference between the light that came all the way through and the light that got diverted by a couple of millimeters, because those couple of millimeters, even at the speed of light, causes a tiny delay before it hits the detector in the picosecond scale, that's a trillionth of a second, and light travels a third of a millimeter in a picosecond, and the fact that we humans can create something that is that sensitive is just kind of awesome.

Mary Lou Jepsen: It is. And it's how lidar works, too, for the autonomous vehicles. They call it time of flight, because it's literally measuring the third of a millimeter per picosecond. It's how fast the detectors are, the camera chips, if you will. That's another word for detector.

Rob Reid: And then if you have that kind of sensitivity and you say, okay, the light pulsed and I'm just going to throw away all these laggards and just take the ballistic light, then you have something that's very much like an x-ray, right, because that light has gone right through and we just ignored all the stuff that got diffused.

Mary Lou Jepsen: Right, because it didn't get scattered.

Rob Reid: And because you can tell this stuff got here first, this stuff got here second, you can toss all the stuff that didn't go straight through.

Mary Lou Jepsen: Right.

Rob Reid: And you had seen some work that was done, was it at Washington University in St. Louis?

Mary Lou Jepsen: Yes.

Rob Reid: Around 2014, and they've kind of done this, right?

Mary Lou Jepsen: Yeah, they've created a system using near-infrared light that matched the resolution of functional magnetic resonance imaging.

Rob Reid: They've basically done an optical MRI. An MRI itself, of course, is magnetic field. So they had done it optically. That blew your mind.

Mary Lou Jepsen: Amazing work, yeah. They got rid of the two-ton magnet and the liquid helium and they made this sort of 50-pound, fiber optic wig that looked like ... I'm trying to think of some-

Rob Reid: Steampunk-

Mary Lou Jepsen: Yeah.

Rob Reid: ... something or other. Very expensive setup, then. They have a 50-pound fiber optic wig, which can't be cheap, but they did it. Let's talk about what you're doing with the light that's special. If I'm not mistaken, the key to what you're doing is the scattering of the light that isn't the ballistic light is not random, but it's predictable and also reversible, correct?

Mary Lou Jepsen: Right, and it goes back to the people that made one of the first display holograms. They made it of a train set, and it made a lot of waves in the optics community in the late '60s. So the next experiment they did was they put a big scatterer in front of a whole sheet of glass that scattered the light in the holographic setup, and it turns out that they could actually reconstruct a 3D image of the train through that scatterer. And so as I was thinking, I realized, "Oh, my gosh. We could do this with holography." We could do this with holography because the pixel size is approaching the wavelength of light, so you can sample all of the light in terms of not just recording its intensity, but you can capture the phase of the light, the wave nature of light, which gives you all this extra information. You can then basically neutralize the scattering of your body mathematically with pretty simple transforms.

Mary Lou Jepsen: So with that, you've reduced the cost of literally [inaudible 00:27:27], like a two-ton magnet filled with liquid helium, the most expensive room in the hospital, to liquid crystal displays and camera chips that are made in factories that supply the world's smartphone and consumer electronics industry-

Rob Reid: Made in massive, massive quantities.

Mary Lou Jepsen: Massive numbers.

Rob Reid: And so if I can just replay that, and tell me if I'm understanding this properly, you've taken a holographic technique that dates back a number of decades and applied that to the scattered light, so that you can use all the light, and so the scattered light, which is an overwhelming majority of the light, that would be thrown away in the first example that I gave, that actually becomes useful data. You can use that scattered light to create an image of the three-dimensional landscape that that light went through.

Mary Lou Jepsen: So you get much higher resolution, because if you think of light going through your body, this ribcage, the other rib, they're all on top of each other. You get kind of a 2D picture of a 3D thing, if you think of the sort of shadow casting.

Rob Reid: Sure, like x-ray is very much a 2D experience, looking at an x-ray, yeah.

Mary Lou Jepsen: Right, and you can do so-called tomographic and take different pictures from different sides to add that up, but when you actually capture all of the light in terms of amplitude and phase, you get much, much higher resolution, much better signal to noise ratio, a lot more light, and you don't have to deal with the shot noise that you get on a picosecond detector.

Rob Reid: The interesting thing that people may not be realizing is we're not talking about massive improvement strictly vis-à-vis a very expensive academic array that sits in a lab in St. Louis. We're talking vis-à-vis MRIs, right, so if one were to build an MRI-like machine with this technology, how much cheaper would it be, how much smaller would it be, and how much higher the resolution would be versus an MRI?

Mary Lou Jepsen: The first ones will be more expensive, but at scale, we leverage the consumer electronics manufacturing industry, so it'll be the cost of a smartphone, and a scan for the cost of a phone call. So a thousand times cheaper, a millionfold smaller, fitting into a wearable, like a ski hat or a bandage.

Rob Reid: And the resolution would be substantially higher, too-

Mary Lou Jepsen: The resolution is higher. We've been able to get about a billion times higher resolution. Now, we don't know if we're going to do that for our first product, but that gets us to neurons, which is pretty exciting. So we can do this noninvasively, look at neuron activity. I think per chip, we could probably do up

to probably a million neurons a second, which everyone says is utterly impossible, and it's like, actually, if you rethink it, it is in reach.

Rob Reid: Just because we've started on it, let's stay briefly on the medical thing and then go to the neuroscience. Let's go back to mammography and this tragedy that breast cancer cannot be monitored by MRIs because it's so expensive. How might that be cured?

Mary Lou Jepsen: Sure, so you can imagine a bra, for example, that instead of a monthly check, you could just put on the bra once a month and wear it for an hour, wear it for a day, and you'll get a lot more data on what's happening and a lot more precision.

Rob Reid: Now, another one of the cool things about the color red, and I guess we could say the color infrared, is blood is red, and so there's a lot of things that you could eliminate, like clogged arteries, right, with this kind of technology?

Mary Lou Jepsen: So yeah, clogged arteries, we can find out where the blood is and where the blood isn't, and that's pretty important for cardiovascular disease, and so if we can find out where you're clogged up, there are some solutions. Could we prevent stroke and heart attack by understanding somebody's at risk earlier? Because there's very often not many symptoms. In fact, for women that have heart attacks, they usually have no symptoms and then they're dead.

Rob Reid: Wow.

Mary Lou Jepsen: So can we find that out? And then on the flip side, cancer, any tumor bigger than a millimeter or two grows vasculature, and it's sort of strange vasculature. It's leaky and it supplies the cancer with the blood it needs to grow fast.

Rob Reid: So to put that in civilian speak, vasculature, it grows its own blood supply. It taps into nearby veins and arteries that comes into it.

Mary Lou Jepsen: Right, steals the blood to grow the cancer, because it wants to grow-

Rob Reid: And so you can see this little highway of blood going into this rogue entity, and it's a distinctive highway, from what you just said. It looks weird.

Mary Lou Jepsen: Your body is about 3% blood, but your tumors are something like 15% blood. So we can look at that and we can look at the shape of arteries or the veins that are growing around it, as well.

Rob Reid: As I know from our good mutual friend, Jeff Huber, who has done a lot of work in liquid biopsy, even with the blunt instruments of treatment that we have today, if you detect a cancer at stage 1, your survival rate can be typically north of 80%, whereas if it's asymptomatic, as tragically, most cancers are, and you don't detect it until stage 3 or 4, your odds plummet to 15 to 20% survival rate.

So that early detection, that can save a factor of four times as many lives. So detection is a really big deal.

Mary Lou Jepsen: Yeah, I think that's why Jeff founded and was the CEO of Grail, where they're trying to sequence your genes so you can create a blood test for having early stage cancer. Even still, where is it? It's hard to find it.

Rob Reid: One other quick thing, going back to blood and its redness, internal bleeding is also something that I imagine would be highly detectable with a system like yours, because again, it is blood and it is red and it is discernible. If you're at a billion times more granular than an MRI, you could find that kind of-

Mary Lou Jepsen: Internal bleeding, bone marrow issues, all kinds of issues with pregnancy. The placenta really is an organ. It grows when you're pregnant. So there's a lot of blood and there's a lot of diagnosis you can have on pregnancy from that, but we can do more than blood. We can get neurons, as I said. We can look at other shapes in the body, but just blood gets you really far.

Rob Reid: So let's now pivot over to neurons and telepathy, which might be entirely enabled by this. So the key thing is, as you said, you can get down to a level of granularity where you can see a solitary neuron. You can see whether it's firing or not firing, and perhaps even cause it to fire.

Mary Lou Jepsen: Right.

Rob Reid: I know from talking to Adam Gazzaley and some other folks in neuroscience, both with this podcast and in other contexts, that using the best technology we have right now, the most invasive technology, technology that very few people would want to mess with in their own brains, at best we can monitor a tiny, tiny handful of neurons.

Mary Lou Jepsen: Right.

Rob Reid: You're talking about monitoring very precisely and noninvasively millions of them.

Mary Lou Jepsen: Yes.

Rob Reid: Let's talk about what this could enable, and how it works.

Mary Lou Jepsen: It turns out we didn't know what the limits of the physics were for this process that we've developed, or this technology we're developing at Openwater, my new startup. And so with my funders, I said, "Look, don't give us a ton of money in the start. We want the first year just to explore the physics," and for anybody doing a hardware startup, I would advocate insisting on that and skipping the minimally viable product. To say, "Look, we need a year of playing around in the lab with a small team to figure out the limits of the physics," because nobody

knows. How deep can we go? What kind of resolution? And the answer to that is six inches and one micron.

Rob Reid: Six inches deep.

Mary Lou Jepsen: Yeah.

Rob Reid: Pretty much the skull.

Mary Lou Jepsen: Well, double that, because-

Rob Reid: Coming from both sides, yeah.

Mary Lou Jepsen: From both sides, it's 12 inches deep, so we're sort of saying, can we get the obese people, and we don't need one micron for the gut, and so-

Rob Reid: Yeah, and certainly not for the head, for the brain. Six inches is quite enough coming in from both sides.

Mary Lou Jepsen: Right, so we can get to a micron, which was startling, and nobody believed it, but we've repeated it and repeated it and repeated it. As we neutralize the scattering of your body, we can see the differential scattering that precedes an electrical pulse going down a neuron is basically a roughening of the membrane, and when a membrane roughens, it scatters light.

Rob Reid: So let me repeat this back to make sure I'm understanding. When a neuron fires, and neurons can do this even hundreds of times a second, its sheath roughens in a way that your technology can discern.

Mary Lou Jepsen: Yes.

Rob Reid: And so you could say very distinctly, "That neuron just fired. That neuron did not just fire," and you can get down to that level of granularity.

Mary Lou Jepsen: Right.

Rob Reid: So now you are hypothetically monitoring many orders of magnitudes, more neurons than can be done with any known technology. As a prequel to talking about how much you might be able to discern with this technology, it'd be interesting to take a brief side journey to Jack Gallant's work at UC Berkeley, which I've seen you speak about on the TED stage and I've seen you speak about online. Could you describe that briefly, this amazing stuff that he did?

END INTERVIEW ELEMENT

Hello again, Ars readers. Mary Lou and I will talk about the amazing work Jack Gallant did at UC Berkeley tomorrow. For now, that's the end of the first excerpt of two from my interview with her. Which, if you're curious, originally ran on my podcast on February 20th of this year.

If you can't wait to hear the rest of it – or, if you'd like to browse my other 30-ish episodes, you can just head on over to my site, at after-on.com. Or, type the words After On into your favorite podcast player. You'll find lots of stuff about life sciences - above all, genomics and synthetic biology. Multiple episodes which are, like this one, connected to neuroscience and consciousness. Conversations about robotics, privacy and government hacking, cryptocurrency, astrophysics, drones, and a whole lot more.

If you like what I do, I hope you'll consider subscribing to my podcast and listening to some of the episodes in archive - all of which were designed to have long shelf lives, and none of which have gone stale yet.

And of course you can join me here tomorrow on Ars, when we'll continue with Part Two of this interview.