**ERIC HORVITZ:** I think that we know so little even today and there’s so much possible, that I think our grandkids will live in a very different world where biology will have played a major role in almost everything that’s being touched, including the materials that we build systems from. And so, I’m very excited about the possibilities.

**KEVIN SCOTT:** Hi, everyone. Welcome to Behind the Tech. I'm your host, Kevin Scott, Chief Technology Officer for Microsoft.

In this podcast, we're going to get behind the tech. We'll talk with some of the people who have made our modern tech world possible and understand what motivated them to create what they did. So, join me to maybe learn a little bit about the history of computing and get a few behind-the-scenes insights into what's happening today. Stick around.

[MUSIC]

**CHRISTINA WARREN:** Hello, and welcome to Behind the Tech. I'm Christina Warren, Senior Cloud Advocate at Microsoft.

**KEVIN SCOTT:** And I'm Kevin Scott.

**CHRISTINA WARREN:** It is great to see you, Kevin, well, you know, virtually anyway. So, are you getting into the rhythm working from home yet?

**KEVIN SCOTT:** I think it has finally gotten a little bit easier. The big challenge for us in the early days of the COVID shelter-in-place was having both of our kids home. So, I've got a nine-year-old and 11-year-old who, like, have the great fortune of being able to do some of their schoolwork remotely. But it also meant having them at home, that my wife and I all of a sudden were teaching assistants once again, and also doing our own IT support for our kids, which was not really what we had signed up for. (Laughter.)

**CHRISTINA WARREN:** Right, right.

**KEVIN SCOTT:** So how has your work changed? I know you traveled a lot. So like, that's obviously not happening anymore. So, how's your team working?

**CHRISTINA WARREN:** Yeah, obviously I am not traveling anymore, right? (Laughter.) That's for sure. Yeah, you know, it's been interesting. Our team was mostly remote first anyway, but this is a different sort of remote experience. So, it's been, I think, good in the sense that we already had experience working together from different places. But it's still different, and we're all I still think, adjusting.

But one of the interesting things, you know, with Microsoft is we're focusing on trying to see how we can do advocacy and events, and the things that I use to travel for online and potentially reach even more people. So, that's pretty cool.

And as our listeners may know, Microsoft Research is actually playing a significant role in bringing our technical resources to the table. And so, today we're going to hear from a Microsoft colleague who is leading the charge.

**KEVIN SCOTT:** Yeah, we're really excited to have Dr. Eric Horvitz on the show today. Eric's one of the most highly regarded AI researchers in the field with contributions that span machine learning, perception, natural language understanding and decision making. His efforts to understand the influences of AI on people in society, including ethics, law and safety, really are paving the way for responsible AI practices.

**CHRISTINA WARREN:** It's such important work. So, let's hear what Eric’s been up to.

[MUSIC]

**KEVIN SCOTT:** Our guest today is Dr. Eric Horvitz. Eric is a Microsoft technical fellow and the company’s first chief scientific officer. As Microsoft’s chief scientist, Eric provides leadership and expertise on a broad range of scientific and technical areas from AI to biology and medicine to a whole host of issues that lie at the intersection of technology, people, and society.

Eric earned a PhD in AI from Stanford and is one of the field’s leading innovators and luminaries. Eric also has the rare distinction of having earned his MD -- also from Stanford -- which gives him a unique view and understanding of the many connections between AI, biology, and biomedicine. I’m thrilled to have Eric with us today. Welcome, Eric!

**ERIC HORVITZ:** Thanks, Kevin, it’s great to be here.

**KEVIN SCOTT:** Yeah, so I’d love to start, as we always do, by understanding how it is you first got interested in science and technology. Presumably, that was when you were a kid. So can you tell us a little bit about that?

**ERIC HORVITZ:** Yeah, it’s -- I just know that I’ve always been sort of inspired to understand things. And I didn’t distinguish between human creations, artifacts, and stuff I would see in the world. So I was confused and intrigued and interested in living things, in space and time. I remember being very, very young asking my first-grade teacher if I could know more about time. She ended up bringing me to the library at Birch Elementary School and showing me a book about clocks.

And I said, “No, I don’t really mean clocks. I mean time.” And I’m also intrigued by light. I had this really beautiful phosphorescent -- phospholuminescent nightlight in the ‘60s, beautiful green light would wash the room at night in this glow. I was curious, what the heck was light?

So, I had these basic questions. I remember having a discourse with my father about some -- I heard a lot about god. I was curious what god was made of, and I couldn’t get a good answer from adults about that.

And when it comes to machines and mechanism, I took apart a flashlight -- I think it was like the summer after kindergarten or so, because I remember in first grade, I was already into this and talking to friends about this. But I realized that there was a circuit there. I found some wire and I think I impressed my family more than myself when I ran around the house with a battery and a wire with a light bulb lighting up in my finger -- under my finger.

And I think this was also around the time that -- again, mid ‘60s when there was a lot of -- you know, a lot of cartoons we were watching back then had electronic robots and Astro Boy flying around and very helpful entities. I was curious about electronic brains. I don’t know where I got that idea.

But I remember having a bag of parts and on the way to my grandmother’s house in the back of the station wagon, maybe this is around second or third grade, but the peanut can wires, light bulbs -- I thought I could assemble an electronic brain on the way to my grandmother’s house in the back of the station wagon. And didn’t get --

**KEVIN SCOTT:** That’s so cool.

**ERIC HORVITZ:** You know, still working on that today, basically.

**KEVIN SCOTT:** That’s really awesome. And were your parents scientists or technical engineers?

**ERIC HORVITZ:** My parents were both schoolteachers. My mother was a kindergarten teacher. I remember being very proud of that in kindergarten. I would tell everybody at a time when the kindergarten teacher was like the person you most looked up to that, by the way, my mom was a kindergarten teacher, too. That was considered awesome by my peers at the time. My father was a high school teacher. He did science as well as history.

**KEVIN SCOTT:** So, where -- I mean, it sounds like you had a bunch of innate curiosity, which is awesome and, like, one of the themes I think we see with a lot of people who chose careers in science and technology, but did you have any role models when you were a little kid or things that were in the popular media that were inspiring you or did this just really come out of, you know, from your perspective, nowhere?

**ERIC HORVITZ:** Lots of books. My parents had a home library filled with lots of books. We had the Merrick Library -- Merrick, Long Island -- where I would spend lots of time. I got to know the science sections as well as the pet section of the library pretty intensively.

Mostly, books at the time. And friends -- some of whom had aligned interests. It’s hard to think of the idea of being in the first or second or third grade having a scientific support team, but we sort of had peers that were interested as well. In third grade, I became -- I was elected to be the chairperson of the science club, I remember. We had all sorts of projects involving wind speed and solar energy back in those days.

But I’m not sure, you know, where some of the interest came from. It was largely curiosity and books. And later in life, of course, I had some fabulous mentors. You know, we all think back to our various teachers in elementary school, you know? You start in kindergarten, go to sixth grade, each teacher has a major influence on people.

And, you know, I can remember sitting at this desk in sort of a -- what I thought was kind of a militaristic setting. And I asked myself on the first day of first grade, “Is this what school’s going to be like? I have to sit at this desk, like, for like 12 years?” (Laughter.)

And the way that first grade went, I was really unimpressed. I would have given it all up if it wasn’t for -- and I’ll call out a name, Mrs. Frank, my second-grade teacher, who, like, completely opened the world to me. Was open to science and interested in answering questions. You know, and then you jump forward to fifth grade, Mrs. O’Hara, and these people were just brilliant teachers -- Mr. Wilmott in sixth grade, where he celebrated my interests and we had science fairs.

I actually won the science fair that year. And you have a few teachers like that who really are, like, are like large planets that spin you up into their gravitational field into new directions.

**KEVIN SCOTT:** Yeah, I think that’s something that we, as a society, systemically underappreciate is the role of these really incredible teachers and what a massive influence they have in your life.

**ERIC HORVITZ:** It’s amazing. Yeah, I’m quite -- yeah, I’m quite certain that if Mrs. Frank wasn’t there in second grade, I’d be doing something very different now in the world.

**KEVIN SCOTT:** Yeah, well and you know, it’s also really interesting. So, would you -- I think to a certain extent, all children have this innate curiosity. So, it’ll sort of be interesting to talk about this later when we are chatting about AI, but in a sense, humans are learning machines and we sort of come into this world and we have an innate curiosity to understand what’s going on around us.

And the thing, you know, for me as a parent that I have really tried to focus on with my children is to do everything that I possibly can to encourage them to lean into and celebrate their own curiosity and to support it in all of the ways that you can, because I have this very strong belief that curiosity is one of these pivotal things that helps you be successful in life, even when you’re not talking about technology or science, you’re talking about your fellow human beings and trying to develop things like compassion.

I believe compassion is rooted in curiosity. It is, like, you wanting to know where another person is coming from or like what they’re thinking about or how they’re processing their world. And so, like, I just -- it’s unbelievably important, I believe, this curiosity, and so wonderful to hear that you had these teachers early in your life who really celebrated that curiosity, rather than thinking it was this annoying thing that was distracting them from what else they were trying to do.

**ERIC HORVITZ:** Yeah, it’s kind of interesting. It’s almost like there is something innate and basic in humans. I’ve heard biologists and anthropologists talk about what makes homo sapien sapiens different than some other even closely related primates. Some of it is this delayed maturation. They talk about this idea that human beings are more kid-like their whole life than closely related species -- “kid-like” referring to puppy-like curiosity that continues on.

This idea of continuing to explore versus being locked in. And anything we can do to promote I think which is very much a human -- probably makes us more human than we know, deep, unrelenting curiosity I think can go a long way for individuals and for society as a whole.

I was thinking years ago, about how much pleasure I get. It’s almost like raw pleasure with getting an answer -- this tension combined with a little bit of awe and mystery of a question building and the pressure around that and how when it gets resolved into a partial answer, the gradient that you’re on and the kind of pleasure you get traveling through that terrain is so deep and great. It’s like one of the deepest pleasures I know -- these bursts of insight.

And to think that in some people that might be linked to pain, “I don’t want to go there,” and the fact that that could come from the nurturing that led to that kind of shift of the natural pleasures of learning and growing, to a painful, “I don’t want to go there because I don’t want to learn something new” for whatever reasons of background, is very sad.

**KEVIN SCOTT:** Yeah, well, I know even myself, like, there is a certain degree of discomfort to being fully immersed in a problem because, like, I don’t know about you, I tend to get obsessed with questions and trying to find their answers.

I remember when I was in grad school, I would be working on proving a theorem and you know would -- some of these things, I’d spend days on. And I, on multiple occasions, I would be so immersed in the problem that I was trying to solve that I would dream about it. And, like, several times, I dreamt the solution to a theorem I was trying to prove.

And I would wake up and, like, “Oh, I got it now!” And I’d go write everything down before I forgot. And, like, that is -- it is, like, I experience that sometimes as discomfort. So, I like totally understand what you’re saying about this. You know, like, sometimes maybe people experience a little bit of fear and anxiety when they are approaching an unknown.

**ERIC HORVITZ:** Right. And they have to get used to the notion that -- or get familiar with the idea that-- there are pleasurable bumps along the way, and a pop toward the end when you get near a solution.

You know, for me, it’s similar. Sometimes I’ll have a problem. I remember from my dissertation work, actually, at Stanford I was really at a time -- worrying about this tension between how do you do things formally with probability and decision theory when it’s intractable and when you needed this kind of reasoning to do some good work in high-stakes decision problems?

And just being at loggerheads with the contradiction. I remember actually where I was at the moment. I was visiting my family and cleaning the garage. I’m not sure how they got me to do that on this day, but I actually had this image of looking at this, you know, stuff scattered throughout the garage, and in my mind seeing an interesting solution coming to the fore finally just out of the blue that became the kernel of what I ended up working on and the solution to this tension.

So, sometimes you get -- you might run these batch jobs which are just tantalizing and in the background and they’re popping up when you’re driving the car or when you’re cleaning a garage. But you’re online and you’re sort of -- you know, a portion of your soul is really focused on getting to an answer continually.

**KEVIN SCOTT:** Yeah, and I think, you know, the other thing that I will say and then we should start talking about your trajectory a little bit more, but I think there is a very interesting thing about this whole phenomenon that you are describing, where you’ve got the discomfort of the unknown and this sort of tension between the thrill of discovery and the frustration of navigating a problem.

That you can get better at over time if you practice. So, like, the more you do it, the more that you understand that you are going to be able to get these little victories over the problem and, like, hopefully, be able to get to a good solution at the end of the day. And I think as you understand that, it makes you more -- not just willing, but eager to go seek these problems out because it really does become this amazing experience and, like, very rewarding.

**ERIC HORVITZ:** And I should say that it’s not all individual. As I’m thinking about the visceral sensations we have as we think about a problem or ask a question and then pursue and answer urgently or over time, there’s this sense that I’ve had. I remember looking at the stars one night as a young kid, maybe a little bit more into middle school, and feeling anxiety about hanging in 3-space, that the sky wasn’t a bowl, it was like the sun was one of these stars I was looking at.

I was just hanging out there in 3-space with kind of an anxiety, angst, existential angst. And I remember this warmth when I felt like, yes, but in science, you can talk to people who are worrying about the same thing. It’s kind of almost like a social supportive experience where we can all come together as humanity and come to the answers together. It was kind of a warmth at that point that this wasn’t just me alone sitting there hanging on a star, but it was a group. We can work together on this.

**KEVIN SCOTT:** Yes, I definitely agree that that’s a really important part of how the whole scientific process works, like, the fact that there is a community that you’re supporting one another and, like, honestly, the problems that we’re trying to solve right now, and we’ll talk about some of these later, are so complex that you know, this notion that a lone genius can go do something that is, you know, like really revolutionary, has always been a fiction. You know, like we’re always building on what others have built before us. And in many cases, the problems themselves that we are trying to tackle are of such vast complexity that you have to have lots and lots and lots of people working on them simultaneously in order to make real progress.

**ERIC HORVITZ:** Right.

**KEVIN SCOTT:** Yeah. So how did you -- so you went to Stanford. How did you decide to go to Stanford? What was your major as an undergraduate?

**ERIC HORVITZ:** So, as an undergraduate, everybody in my family, we all went to state schools. I think I spent an afternoon on a ping-pong table filling out a form. I wasn’t thinking much about college, I just said, “You know, that’s what we do.” I went to the State University of New York at Binghamton, which was the top school in New York when I was applying to schools.

And when I got to university, I just absolutely loved every class I was taking. And I said, “I’m curious about physics and biology.” Those two things were like where most of my curiosities were clustered. And so, I started taking a bunch of physics classes and a bunch of biology classes, biochemistry, and so on.

And at some point, I didn’t want to stop looking at both. I went to a mentor/advisor whose class I loved; he taught a class in biophysics, believe it or not. I said, “Yeah, this is great.”

And I asked him, I said, “There’s no major in *biophysics*, what do you think it would take to do a special major in this area where I can really work with you in putting together an undergraduate sequence that would really capture what you would do if you were going to study this area even as an undergrad?”

And this was Professor Starzak. And we sat together and came up with a program and took it to what called the Innovative Program Board and a committee looked at this proposed major and they said, “Good to go.” There were a lot more classes in this and directed readings with some incredible professors. But I felt like I had the best of both worlds. I had chemistry, physics, math, bio together.

And in the middle of all this, I ran into two professors as I was getting to junior year and senior year who both were just remarkable. One professor is Howard Pattee, who was a professor from Stanford, actually. He did his PhD at Stanford, and his interest was emergent phenomenon. And particularly, he looked at biology from the point of view of a physicist –and *symbol systems.* And he wrote some beautiful pieces and essays that are still celebrated. They not too long ago had a celebration of his career.

I was immersed in Howard Pattee’s readings and thinkings, which were very deep and interesting and cutting to the core of, I would call, the theoretical foundations of biology from the point of view of a physicist.

And at the same time, I started talking to Robert Isaacson, who was taking a biophysics perspective on brains, looking at limbic systems in rats. So I started talking to him, he persuaded me to work in his lab. I started looking at these living neural networks.

And I started getting very interested in brains. I hadn’t really been thinking a lot about brains and minds since trying to build an electronic brain in first and second grade with peanut cans and springs and wires and clay and light bulbs.

So, right towards the senior year, I was trying to pull together my biophysics background, into looking at how brains work. I ended up reading a couple of books. One was Herb Simon’s book called *Sciences of the Artificial*, and another book was Michael Arbib’s book *Brains, Machines, and Mathematics*. And both were very motivating to me in terms of the questions that were being asked. And so, I ended up applying to graduate programs which combined neurobiology with an MD. I thought, “Why not get into the human -- have this human dimension to understanding the clinical worlds. Someday, we’ll understand brains.” So, I ended up getting a bunch of acceptances and had to choose among places that had more of a mix of things and flexibility around your degree, and other that would be very classical MD/PhD work, and very focused. And I ended up –on a set of intuitions—thinking through that Stanford might have more of the mix that I was looking for, but I wasn’t sure, because by the time I ended up going to grad school, I was really zooming toward *computation* at a time where you wouldn’t be thinking as an undergrad, you know getting into the ‘80s, about *artificial intelligence*. You’d be thinking about neurobiology, neuroscience, biophysics.

And so, when I hit Stanford, there I was interested in getting going on neurobiology, being thrown, believe it or not, into a medical school class with a cadaver, where I ran into some close colleagues who actually had similar interests to mine.

At Stanford, you can wander off to the main campus, which was just a bike ride away. So, I spent a lot of time in my first year taking classes in computer science, artificial intelligence, philosophy of mind, and cognitive psychology, along with the regular medical school classes.

And toward the second year I said, “You know something, I need to -- I don’t think neurobio is going to have the right mix for me in my pursuit of my core curiosities about what the freak was going on with minds, with human brains, and brains of vertebrates and other animals on the planet.”

And the fastest path to insights would be through computer science. And I remember one of the moments I was thinking about what I’d been doing in my laboratory work that I became very good doing unit recordings, looking at small circuits, listening to the ticks on a speaker in a darkened room, looking at the oscilloscope on interesting questions about how particular subsystems worked, the thermoregulation subsystem in a rat, for example.

And thinking that what I was doing all those years was sticking a thin wire into a chip trying to infer an operating system and the application code, and even the hardware by listening into the Morse Code of a single gate.

And I felt like that would be a waste of good time on the planet. And I remember thinking it was a major shift to say, “I’m going to give up the pursuit of a neurobiology, neuroscience PhD.” And I’m going to move over now to go all—in on what was—I came to know as artificial intelligence research, history, depth -- you know, all the methods-- I wanted to really master it.

**KEVIN SCOTT:** And, you know, it’s sort of an interesting time in the ‘80s for AI. So, you know, one of the things we’ve chatted about on the podcast before is the fact that AI has had this distinct cycle of booms and busts over the years that, you know, the Dartmouth workshop in 1955, the program that McCarthy and these luminaries put together was way more ambitious than they -- you know, in reality were going to be able to accomplish.

And, you know, that we have had several of these cycles where the enthusiasm and the expectation for what we were going to be able to accomplish has sort of far exceeded our ability, which leads to these AI winters where you’ve got a bust and, you know, like people sort of go sour on the whole discipline.

And like as I remember it, like the ‘80s, I forget what time in the ‘80s, but like by the time I got to grad school we were -- we were on the, like, well into an AI winter, where it was no longer like this fashionable thing in graduate programs.

So, you -- when you got into AI, was it right before the AI winter that we had or, you know, was Stanford in some way like a unique island where the enthusiasm for the field was undiminished over time?

**ERIC HORVITZ:** Well, first of all, I want to make a comment on that 1955 proposal. I’ve often said that that proposal is written so well and it’s so aspirational that if you submitted it today to DARPA or the National Science Foundation, you’d probably going to a high grant score and be funded, so just go for it.

I mean, as written. So, back to your question. When I first jumped in, it was ’84. It was kind of a warm time and getting hotter. It was the time where the rule-based expert system, these production systems that, for example, backward chaining through these modular human expert rules were becoming quite popular.

And I remember one of my first meetings was IJCAI at UCLA, and it was just an amazing time of excitement and inspiration with thousands of attendees. It felt like NeurIPS feels today. But ’84, ’85, ’86, there was kind of a collapse of interest and a bunch of startups going out of business that had been funded during the earlier time when it was discovered it was just kind of hard to build these systems and maintain them and maybe these logical systems weren’t as powerful and as promising as people thought they’d be, and weren’t as easy to use or build.

I looked over the history quite carefully and you know, what’s called “AI Winter” for us -- and I say us -- it’s I and students at Stanford that were studying similar topic areas, and we had very close friends that we met at conferences and workshops at MIT and CMU and a few other places that created this invisible college of grad students that were looking for a different way to do things.

And in many ways, we were up against the glowing cinders -- you might call them ashes -- of what had been really exciting just two or three years before, typically pioneered by the people who were our mentors and advisors, which created some tension.

And what we were looking for was going back to the basics and building on the shoulders of the great statisticians and probabilists and folks who had done inference and optimization over decades. We discovered that the AI of the time and in the early ‘80s to mid ‘80s was defining itself as, “No, no, no, no, that’s Operations Research’” Or, “No, no, no, there are too many numbers there. Numbers aren’t symbols, we want to manipulate symbols.”

There was lots of tension there, and at times, for me in particular, I specifically sought out new advisors at the time and moved over to working with George Dantzig, who was an Operations Research leader who, if people know his work, his fabulous personality, but his intellectual contributions include the Simplex Method for optimization.

**KEVIN SCOTT:** Yeah.

**ERIC HORVITZ:** And Ronald Howard, who had defined the phrase “decision analysis” and was really interested in thinking through, “How do you build systems that can help clarify thinking and bring together multiple factors under uncertainty?”

And what I found in George Dantzig and Ron Howard, decision theorist and optimization probabilist, and folks like Brad Efron in stats, were they were looking across campus at the AI people and thinking, like, like, “What the hell are those people thinking?” (Laughter.)

And so what I started doing, I felt like -- and I wasn’t just me -- there’s a few of us in -- I had a close colleague, David Heckerman, Michael Wellman at MIT, Oren Etzioni at CMU, and others. We started to think through, like, what were the big questions in AI?

Even going back to the 1950s documents and before, and how could we start to build on what we knew was kind of the science of optimization, decision-making, action under uncertainty, high stakes consideration of preferences, tradeoffs, and start pushing in a direction that at first was considered quite foreign and outside of AI—"Not AI.”

A very distinguished professor told me after listening to me talking about bounded rationality with using probability as the basic fabric and decision theory, he said, “You know what? You have something we call ‘physics envy’.” (Laughter.) Referring to Freudian notions of another kind of envy.

And you know, you really need to look at symbols and high-level manipulation of predicates, go back to theorem proving, you’re really wasting your time with these numerical methods. They called them numerical. Even as we were coming up with abstractions like Bayesian networks and influence diagrams, which are higher-level constructs, representations. And I remember at the time we were joking about getting bumper stickers as grad students -- rebellious grad students -- driving around campus that were going to say “Numbers are symbols, too.” It was that bad in those days.

**KEVIN SCOTT:** You know, it’s really interesting, though, because what you all were collectively doing, you know, sort of steering things away from this symbol manipulation, like systems of logic, you know, sorts of research and getting things into this more, you know, statistical framework has basically set the course for artificial intelligence over the past three decades.

Most of what we talk about now when we’re talking about artificial intelligence is statistical machine learning of some flavor or another. And like that’s really sort of a stunning thing to like have that foundational piece persist for as long as it has. I mean, so like I don’t know whether you all were cognizant of what you were doing, but like it’s a really big deal that the field pivoted that way.

**ERIC HORVITZ:** Rather than being cognizant, we felt like we were outsiders with some really important ideas to share. There was a panel at AAAI in 1984 I recall, where several people were almost booed off stage as we tried to bring up this idea of uncertainty in AI -- principles of uncertainty.

And that next year in 1985, we decided to take that panel and make it into a workshop we called Uncertainty in AI, (UAI) which was a separate growing community.

I remember the moment this outlandish thing happened in 2007, I was invited to be the president of AAAI. We joked – “we” being the former invisible college -- that the revolution was complete. And it really felt that way, like, all of a sudden, we said, “You know, look—I remember in like 2010 or so) you know, AAAI we said, it’s like UAI, it’s like a big UAI now, it’s everything.”

**KEVIN SCOTT:** So let’s, you know, since I want to make sure we get to some of the like really interesting stuff that we’ve been doing recently, let’s fast forward all the way to some of the AI work that you’ve been doing over the past handful of years, which I think is of, like, again, really foundational importance, like, maybe even more important than this shift that you all agitated for and sort of realized when you were grad students.

And that is sort of thinking about AI in the human context. So, as these technologies have become unbelievably more powerful, like especially over the past 10 or 15 years and their applicability to problem solving in the real world has never been higher, we are now being faced with a whole bunch of questions about what’s the ethics of applying this particular algorithm or technique in this scenario? Like, how do we make sure that these systems are doing things in unbiased ways?

Like, what is fairness in these systems? Like, what are the things that we shouldn’t use AI for? Like, where are the places where AI should always have decision-making systems where there should always be a human in the loop?

And so you’ve done, I think, some of the really most important work in the field at Microsoft and in these organizations that you have helped to start and are sort of involved in the leadership of, like the Partnership for AI, on thinking about what the -- you know, the ethical and responsibility frameworks are for doing AI in a modern world. So, like, how did you decide that that was something that was going to be such an important focus for you?

**ERIC HORVITZ:** I’ve always been interested in high-stakes decision-making -- decisions that really make a difference in the world. This is why I went to probability and utility theory, to have formal foundations for these actions and recommendations -- applications in healthcare.

And, you know, back in the ‘80s and early ‘90s, our goal was just to get something to work. But even during those times, we saw interesting challenges with moving these systems into the actual world of usage, like doctors who wanted to understand, like, why the system made a recommendation, who would say things like, “No, that can’t be right. Can it explain itself to me?” and coming up with methods to do explanation even in the late ‘80s?

Seeing how important that would be, this human connection. I remember working on a project where NASA mission control in Houston—the last year in my dissertation work, looking at some high-stakes decisions, time-critical decisions with propulsion control people, and I realized that it wasn’t just *making recommendations,* it was figuring out *what to display to people* to help them make a decision.

So, there’s this open-world issue that became very important to me as part of understanding the bigger role of AI in larger human settings. To me, it was more or less obvious in high-stakes areas, you had to consider these things.

And then when I was becoming the AAAI president, it was a time where there were lots of initial discussions about “the Singularity coming” and there was both Utopian and dystopian views being debated.

And so, I decided to make the theme of my presidency, “AI in the open world.” And there’s an open world of, “How do you put a system that’s limited into more complex worlds and give it the ability to understand its own abilities” and to be really much more omnipresent about the reality of helping humans out or controlling a system that has a function in the world, not just this narrow wedge of expertise on a certain particular classification topic or prediction.

And a second theme was thinking more deeply about the influences of our projects in the world. This is 2008. And when it came to that part, in my presidential address -- each president gives an address -- I talked about the technical aspects and the social and societal aspects. And I called together a group of about 25 people to create a study that I called the *Long-Term Futures of AI* *and its Influences*. And we had three subgroups meeting.

And we ended up doing something very interestingly and analogous to the Asilomar meeting that the biologists had held in 1975 I think it was looking at recombinant DNA. We ended up doing a workshop -- and three-day workshop at Asilomar, where we all came back from our breakout groups to do reports. It was the first time I heard this phrase from this short-term, acute challenges group. We had a long-term group, a short-term problems group, and then an ethics and legal team as part of this effort.

But it really drew me in and got me excited. I remember this phrase, “criminal AI.” And I said, “Wow, what is criminal AI?” And this group reported their findings about the malevolent use of AI by state and non-state actors and where it could go.

We had another team -- I specifically asked a team to look at could they take something as -- might call it fanciful, but interesting as Isaac Asimov’s *Laws of Robotics*, which folks have read about in his robot series, and actually codify them in a system with modern AI techniques so that the system could be proven to be reliable and responsibility to human beings and to society.

And we had a great breakout session on that topic. And we looked at ethics and legal issues. So, that whole experience and working with the community on these topics, which resonated deeply with me, per my interest in seeing these technologies do well in real hard decision problems and recommendations, further pulled me into thinking more deeply about the role that we would have as researchers, as scientists, as professionals, and as companies in thinking through not just the technology itself, which was growing in its power and its usage in commerce as well as in areas like defense and healthcare.

But to really consider deeply what we might do as a growing field, including technical issues, social issues, looking at the human dimension, you know, if you people are using these systems, how do you design them in a way not just to -- where they might explain their reasoning, if people want to know what’s going on, but how do you understand how to apply the technology in a way that will complement expertise that’s already available from human beings?

How do you think through longer-term futures where the technology begins to shape the nature of work and the nature of the tasks people do in particularly named jobs, like I’m a doctor, I’m a lawyer, I repair automobiles. To understand what it all would mean so that we would know how the role of humans would be co-evolving with the role of machines.

And then, it’s just been so rewarding to see the rise of a whole field, studying problems that are also rising in issues, for example, around the bias of systems that are trained on data that comes from cultures and society that have all sorts of nuanced histories that lead to sampling issues and data that represents the societies from which it came and systems that you can build from that data that will amplify existing inequities in society.

So, to see, there’s actually a rising field now of people that are pointing out these examples and coming up with ways to better visualize and understand and address them.

**KEVIN SCOTT:** So, the thing that I want to chat about now is sort of the future. Like, the things that it seems very likely to me that we’re going to want to apply our most powerful technology platforms, including modern machine learning to over the course of the next several decades.

And I think, you know, perhaps the most interesting area or sort of intersection is what’s happening right now in biology and how that intersects with the work that’s going on with AI and high-performance computing.

And, you know, it was sort of an interesting intersection and has been growing increasingly interesting over the past handful of years, and now it’s just sort of acutely interesting and urgent and necessary because of all of the work that we need to do to adapt ourselves to handling the COVID-19 pandemic.

So, you might not have realized how prescient you were when you were choosing to get a PhD in AI and a medical degree, but like you’re in this interesting position now where you have this background and point of view of visibility into like this intersection. I'd love to hear your thoughts about where you think things might be going over the next handful of years.

**ERIC HORVITZ:** Yes, it’s pretty impressive to see the connections between computer science and ideas of abstraction, modularity, the ability to simulate in computer science and where it’s touching on biology.

And even back to the early ideas that I studied with Howard Pattee on looking at biology as a physical system that had certain interesting properties that most of the world might look at as magic or in a different category, but in reality, is a very interesting set of mechanisms that even relies on, for example, higher-level abstraction, the way our programs do.

**KEVIN SCOTT:** Yeah, so the -- you know, one of the things that you and I saw recently, like we went to chat with Drew Endy at Stanford. And, you know, one of the things that he said in that conversation thought was so interesting to me is that now that we understand -- and like we’re still early days, but like we understand a little bit of how to program or reprogram biology to do different things than what the biological systems do on their own.

And like one of the things that he mentioned is that you know, you have yeast, which are basically little breweries, like they are biological organisms that transform, you know, things into, you know, like carbohydrates into carbon dioxide, you know, and alcohol, for instance.

But, like, you can -- you know, his assertion was, like, you’ve got these yeasts that we could reprogram to brew a whole wide range of compounds that we can use, for instance, as we pursue sustainability. So, like, things that might be alternatives to things that we would synthesize with petrochemicals, for instance. And that’s a really exciting idea.

**ERIC HORVITZ:** You know, we are in the early days of a major revolution in our ability to manipulate the physical world. Biology has figured this out in beautiful ways, has built beautiful mechanisms that synthesize, that do incredible acts of chemistry and physics that are robust, self-replicating, the spinning out of shapes and structures through embryogenesis.

Just these magical – because we don’t understand them -- capabilities are coming into focus now through the lens, in part, of computation, physics, biochemistry. But perhaps the biggest insight in terms of the lens and the capabilities and the opportunities I think are at the intersection of metaphors and concrete mechanisms from computer science staring directly at biology and looking at the information theoretic aspects of what goes on in biology and then thinking about how these things can be -- these systems can be harnessed in new ways, as well as borrowing ideas from biology and thinking through how we build systems, how we design materials and so on.

But your comment focused more on how can we better modulate, moderate, design biological systems to do new acts of creation with applications in biology and applications in healthcare and applications in material science, applications in neuroscience.

I think that we know so little even today and there’s so much possible that, I think our grandkids will live in a very different world where biology will have played a major role in almost everything that’s being touched, including the materials that we build systems from. And so, I’m very excited about the possibilities. It’s bringing me back to my roots of biophysics, now combined with computer science and artificial intelligence, so I’m happy to be in this new role.

As we’ve been talking, to start thinking deeply, working with partners like Drew Endy, David Baker, Georg Seelig, so many people that really are lit up now with thinking in this way of looking at what we call a rising field of synthetic biology, how do you program biology? How do you guide it in new ways? How do you understand and control cancer? You know, it’s a runaway program.

And you can just -- we can just go topic by topic and think through what the engineering paradigm shifts we might need to design new kinds of robust and predictable functionalities in biological systems. You know, even something like the magic of something like the ribosome. We’ve all learned about the ribosome in basic biology classes. Oh, it’s this interesting coalescence of RNA and protein in a structure that takes symbols and builds effectors and structures. It’s one of these key, we’ll call it a key pivot point of what makes biology “biology.”

You know, storing up coincidences and insights in long pieces of tape called DNA, the ability to take those codes as they’ve been learned and to transform those codes into structure and function, and then to have experience reencoded through evolutionary processes back into that tape.

But this idea of a ribosome, you know, what do we understand and what can we better understand about this hinge point between information and the physics of life. I think has a lot to say about many things that we do.

**KEVIN SCOTT:** And, you know, the way that you just described that, like, I hope that that is one of the exciting and inspirational things that kids today will sort of see. Like, in fact, if someone had as eloquently described genetics and the mechanism of the ribosome when I was a high school student as you just did. I may have chosen to pursue a different field.

But I think we are this incredibly inspiring moment where, you know, not only will our kids, grandkids live in a much different world because of what we are able to do with our new understanding of how to leverage biology to help make people healthier and help maybe make our physical world more sustainable, but like I think they actually are going to be the ones who you know take inspiration now on what’s possible, and they’re going to go build this world. And, like, that is super exciting.

**ERIC HORVITZ:** Yeah, absolutely.

**KEVIN SCOTT:** Cool. So, we are just about out of time, but I’ve got one last question that I wanted to ask you, so I’m always interested about what scientists and technologists who are, you know, themselves inherently curious about the world, like, what do you do for hobbies? Like, what’s a thing that people might not know about you?

**ERIC HORVITZ:** That’s interesting. Well, I try to get exercise. And people might not know that I’m a Hacker, which is – I just stopped playing, but I’ve been playing ice hockey in the Greater Seattle Hockey League for a number of years on a team called The Hackers.

It seems that most of our opponents think that we’re actually a different kind of hacker. (Laughter.) But, so I find it’s -- one place where I turn off everything except really focusing on teamwork and where the puck is and being out of breath and how fit I am. I’ve loved those kinds of sessions being out on the ice.

I just decided to step off the team when I was getting busier and busier and I was actually one afternoon very grumpy at an All Hands meeting at Microsoft. And I’d just come back from a game from Everett like at 2:00 in the morning and I decided, you know what? I just can’t do this anymore.

So, instead, I took up inline skating now, believe it or not. But I wanted to be serious about it. So, during NeurIPS for example this year in Vancouver, I went to this custom blade shop and I had like these marathon blades made. And I committed to being in the Berlin Inline Skating Marathon on September 26th. And just last night, I was worried about this, they popped up a message saying they’ve canceled it and they’ll be in touch with us. But I was training for the Berlin Inline Skating Marathon, down the streets, up and down here with these new Vancouver blades that are just like magnets on the asphalt. But I do like to get out and get my mind focused on just clearing it with running or skating or paddle boarding.

Other kinds of things, I enjoy reading. Just coming off a really interesting book. I tend to read science magazine every week, and there’s a great book review they do of books coming out in the sciences. I just finished this book called *Becoming Wild* by Carl Safina.

Which is looking at animal culture and looking at, for example, sperm whales, and it’s just really amazing to read about the interaction of - or the importance of culture, stuff that’s passed down among animals versus being in their genetic code for thousands of years -- tens of thousands of years -- and different cultures even with the same species living side by side, different dialects that are spoken by whales, for example.

I’ve always been interested in -- and this gets into the AI in the open world question, but even brains in the open world. How do human beings -- how did our minds, nervous systems co-evolve with our culture, co-evolve with tools like language?

And so I found lots of interest there, you know, in that recent book that I read, with core questions that I have about the role of our external world and our tools like languages with the shapes and operation of homo sapiens nervous systems.

**KEVIN SCOTT:** That’s awesome. So, this has been a great conversation, Eric. Thank you so much for taking time out to chat with us today. I really, as usual, enjoyed hearing more about what you’re thinking.

**ERIC HORVITZ:** Yeah, well, great catching up, Kevin. Looking forward to continuing our discussions.

**KEVIN SCOTT:** Awesome.

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**CHRISTINA WARREN:** All right. So, that was Kevin's chat with Eric Horvitz, who is Microsoft's first chief scientific officer. I loved hearing his story about his journey getting into, you know, tech and medicine, which is such an interesting combination, as well as your kind of broader discussion about ethics in AI and kind of where that future holds.

**KEVIN SCOTT:** Yeah, I think one of the remarkable things about Eric, and this has been true for so many of the guests on the podcast and so many of the people that I have the good fortune to know working in technology, is that one of the things that motivates them and that has motivated them since they were really young children is this voracious curiosity and desire to understand what's going on in the world. And it was really, really great to hear Eric talk about that part of his life.

And, you know, I think part of the reason why he chose to do things the way that he did them in terms of how he approached his education, and how he has spent most of his research career, is because he just refused to decide on, like, one thing or the other. He's like, why can't it be all of the above? And that's really what we need more of when we're thinking about AI, especially as this technology is having a greater and greater impact on society and our future.

**CHRISTINA WARREN:** No, I couldn’t agree because it brings a really good kind of way of looking at the world that you might not get otherwise.

**KEVIN SCOTT:** Yeah. I mean, one of the really fortuitous things about having Eric here at Microsoft and having him play such an important role at Microsoft over the years is that, when a moment like now arises where we really do have to think more comprehensively than ever before about what this intersection is between biology and artificial intelligence, it's pretty convenient to have one of your foremost AI experts actually be a medical doctor as well. It's sort of only at Microsoft, I guess. (Laughter.)

**CHRISTINA WARREN:** It really is. And I mean, you didn't really get into this too much in your conversation, but I just want to ask you, especially since you've written so much about AI and since you've been having these conversations with people like Eric who are experts in biology, what role do you think AI might be able to play, kind of going forward as we're looking at how to combat this and maybe even other potential viruses or health concerns?

**KEVIN SCOTT:** Yeah, I think we're seeing it have a really tremendous impact already. So, you know, as we have dug in with a bunch of the researchers and a bunch of the medical professionals and biotechnologists over the past handful of months, it's already the case that they're using the tools and machine learning and artificial intelligence in relatively sophisticated ways.

So, it may be, you know, on one end of the spectrum, using natural language technology to better extract critical information out of our unstructured health records that are -- you know, for many, many, many years now have been handwritten notes or notes that are taken and input into medical records system. But it's still, you know, it's sort of this unstructured data that we really do need to be able to establish more structure around so that we can do the types of deep analytics that we need to do to, you know, understand things, for instance, like the progression of symptoms of a pathogen like SARS coronavirus 2, and like really try to widely disseminate what effective therapies are that people are applying over time.

And so, you know, funny enough, natural language processing and natural language understanding, which are these classic techniques from artificial intelligence, have huge relevance there. You also see in the work that people have been doing, and we've talked about this some of the podcasts, in using deep neural networks to do medical diagnostics.

So, I'm wearing a ring from a company called Aura right now that measures your body temperature and your pulse, and a whole bunch of things about your movement. And I think this company originally intended to have these rings help you manage your all-in health, like whether you're sleeping well enough or whether you're getting enough exercise and activity.

But it may be the case that the data that's gathered by devices like this are going to be really useful when you are able to train sophisticated deep neural networks with them in detecting diseases like COVID-19, hopefully before you're gravely ill and have time to go get yourself treated so that you can jump back to a robust, good health as quickly as possible.

And then on the, you know, sort of the very far end of the spectrum, which has been some of the most surprising bits for me to see over the past handful of years, is how the tools of AI, like in particular, deep reinforcement learning are almost becoming like a new calculus for the basic sciences. So, you had calculus come about as this analytic framework for better describing and understanding the phenomena in the real world in the 18th century. And you got most of modern science from having a tool like that.

And I'm seeing now with AI deep neural networks and machine learning, deep reinforcement learning, these new self-supervised learning techniques that we've developed over the past handful of years are being applied in science in sort of the same way that you might imagine calculus was many years ago to more accurately and faithfully model the phenomena in the physical world so that you can better understand them. And that might be helping to accelerate a molecular simulation that's trying to understand how the spike glycoprotein in the coronavirus is interacting with your epithelial tissue and invading cells, and infecting you with this horrible disease.

And, like, we are already seeing how machine learning and AI, these new techniques are being used to accelerate those simulations and to get to more accurate results. So, I think there's going to just be a -- almost like a landslide of activity and building momentum over the next handful of years as these two worlds, artificial intelligence and biology, start to intersect in a more profound way.

And I think we're going to spend a bunch of time this season on *Behind the Tech* talking to some of these innovators who are in the biosciences using these tools in these innovative ways to help make us all healthier, and bring better healthcare outcomes, and to as many people as humanly possible and, you know, to use biology in ways that we really weren’t even conceiving of a few decades ago.

**CHRISTINA WARREN:** That's great. I'm glad, I'm glad. And what's great about this, I think it gives us hope, and we need hope right now.

**KEVIN SCOTT:** I know that I'm certainly feeling hopeful.

**CHRISTINA WARREN:** Well, that's a wrap for us today. As always, please reach out anytime at BehindtheTech@Microsoft.com. We'd really like to hear from you. How are you faring during these times? We'd love for you to share some of your stories about how you're innovating, how you're hacking and finding ways to stay connected with technology.

**KEVIN SCOTT:** We'd love to hear from you. Thanks for listening. See you next time!

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