[MUSIC]

**DANNY HILLIS:** Social media is, you know, was never by itself, the thing that was going to, you know, advance humanity, nor is it the thing that's going to destroy humanity it’s actually a tool that we're going to learn to use with time like we learn to use fire.

[MUSIC]

**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. Today, our guest is Danny Hillis.

**CHRISTINA WARREN:** And Danny Hillis, I'm so excited about today's guest. He is an incredible pioneer.

**KEVIN SCOTT:** Yeah, he is. So, Danny is perhaps most well-known, although it's like a difficult thing to say, you know, given how much he's accomplished, like what the single best known thing was, but like when he was a student at MIT, he started this pioneering company called Thinking Machines that built the world's fastest supercomputers and really pioneered a new type of computer architecture that was revolutionary at the time, and that has informed how we build computers even today.

And like he's also been the head of Disney Imagineering and he's got this crazy invention factory company that he runs now. So, like Danny really is like one of the most interesting people I know and like so creative and like such an amazing entrepreneur. I'm super excited to be able to chat with him today.

**CHRISTINA WARREN:** I'm so excited, too. We should get to the interview.

**KEVIN SCOTT:** Yeah, let's chat with Danny.

[MUSIC]

**KEVIN SCOTT:** Today, we'll chat with Danny Hillis. Danny is an inventor, engineer, entrepreneur, and author. As a student at MIT, he founded the pioneering supercomputing company Thinking Machines, which built the world's fastest computers in the '80s and '90s, and paved the way for modern large-scale computing.

After Thinking Machines, Danny ran Imagineering at Disney. He cofounded Applied Minds and Applied Invention, an interdisciplinary group of engineers, scientists and artists. He is a visiting professor at the MIT Media Lab and a great friend.

[MUSIC]

**KEVIN SCOTT:** Hello, Danny.Welcome to the show.

**DANNY HILLIS:** Great to be here.

**KEVIN SCOTT:** So, you perhaps more than any other person I know, like, have a curious and wide set of interests, which is awesome, and I would love to understand, like, how that got started. Like, were you a curious kid?

**DANNY HILLIS:** So, I was really lucky in that I grew up all over the world. My father studied hepatitis, so wherever there was a hepatitis epidemic, we went there and lived.

**KEVIN SCOTT:** Wow.

**DANNY HILLIS:** So, I got to live in countries in Africa that don't exist anymore. But, you know, lots of places in Africa and India I got to live, in Kolkata, and Europe, and little towns in the southern United States, and so, I really, there was always something to be curious about.

**KEVIN SCOTT:** Right. And, like, beyond the exposure to, like, all of these different cultures and people and ideas, like, your dad must have been a little bit fearless and adventurous.

**DANNY HILLIS:** You know, it's interesting, I think in retrospect, he was just naïve.

**KEVIN SCOTT:** Oh.

**DANNY HILLIS:** I asked him, because when I had kids of my own, I was like, why did, you brought us into war zones and stuff like that. I would never do that with my kids.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** And he's like, yeah, we didn't really understand what we were doing.

**KEVIN SCOTT:** But it seemed to have worked out.

**DANNY HILLIS:** It did. And I got to try every possible kind of education system or non-education system along the way.

**KEVIN SCOTT:** So, was he an epidemiologist by training?

**DANNY HILLIS:** Yep, that's right.

**KEVIN SCOTT:** Okay, and what did your mom do?

**DANNY HILLIS:** Well, actually, my mom is a great story, because my mom quit school to put my father through medical school. And I always knew she was super smart. But because she wasn't educated, people did not treat her like she was smart, and she had a southern accent, and in those days that caused you to be ignored.

**KEVIN SCOTT:** Yeah, well, it might still cause you to be ignored.

**DANNY HILLIS:** Well, when I went to high school, she went back to college and finished college. And then, when I went to college, she went to graduate school, and got her PhD in biostatistics.

**KEVIN SCOTT:** Wow.

**DANNY HILLIS:** Yeah, and then all of the sudden everybody started taking her seriously as a statistician and --

**KEVIN SCOTT:** Well, I mean, that is an amazing story. I mean, sad that they didn't take her seriously before she got her PhD in life.

**DANNY HILLIS:** Well, it has a happy ending.

**KEVIN SCOTT:** That's great. And so, when you were a kid it was like, this was before the personal computing revolution, so, like, what was your first contact with computers?

**DANNY HILLIS:** So, partly, I was very fascinated by technology, because I was far away from it. So, I was in places where, you know, it wasn't happening. And so, that made it sort of more enticing for me. And when I was living Kolkata, I went down to the British Council had a library of English books. You couldn't take them out, but you could read them there. And I found Boole's “Laws of Thought.”

**KEVIN SCOTT:** Wow.

**DANNY HILLIS:** And, you know, it was too advanced for me, but I kind of got the basic idea of Boolean logic, and I thought this is really cool.

This is how computers work. And so, I wanted to build one, but, of course, I couldn't. You couldn't buy a transistor or --

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** -- or a relay or anything. So, I built my own switches by using screen from screen doors and nails that stuck into them. And I cannibalized lots of flashlights, and I built my first computer, which was a, basically a fixed logic array that played tic tac toe. So, you would move the switches, and it would light up one of the nine squares.

**KEVIN SCOTT:** Now, that's pretty incredible, actually. And did you have anybody helping you? I mean, like that's certainly not something I would expect one of my children to go figure out.

**DANNY HILLIS:** You know, certainly lots of adults helped me, like, you know, nail the nails in and things like that, but I don't think my parents had much of an idea of what I was doing. But I always got encouragement from the people around me, and I think that that's one thing, I mean, I did a bunch of crazy, stupid things that didn't work too, and I got encouragement on those too.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** But that one worked.

**KEVIN SCOTT:** How?

**DANNY HILLIS:** And so, you know, they always, they gave me a lot of, a lot of freedom to make mistakes. And so, you know, that was in a lot of mistaken, crazy projects that didn't work, but that one did. And so that kind of got me on a course, and then actually won the special prize in the all-India science fair. So, that was the --

**KEVIN SCOTT:** That's awesome. And, like, that must have been, like, a really important thing, like, getting encourage at the right point when you're young, sort of, like, almost starts a positive feedback loop.

**DANNY HILLIS:** Oh, it absolutely does. And people who are interested in what you're doing and it doesn't really necessary -- it's not really necessarily they have the knowledge, and in some sense, maybe I was a little bit lucky that they didn't have the knowledge, because I kind of had to figure it out of myself in a way that but I had resources, like the library, for example.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** And, you know, I always had people that were willing to help as much as they could and so on.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** So --

**KEVIN SCOTT:** That's really interesting.

**DANNY HILLIS:** It's so different than the world we live in now where, you know, of course, anybody can find anything on the internet. But in those days, it was really very hard to find information about things.

**KEVIN SCOTT:** And, so, I wonder about this all the time, because I, like, when I was a kid in the '70s, it was still too, or, so internet, right, no Google, no Wikipedia, no, like, and you had to, like, we were relatively poor, so, like, we only had a few books in the house, and, you know, my, my parents had bought a World Book Encyclopedia from one of the, like, encyclopedia sales people --

**DANNY HILLIS:** Yeah, mine did that. Yeah, yeah.

**KEVIN SCOTT:** -- and put it on a payment plan. But, like, you had to go to the library really to go get books. And I sometimes, like, romanticize this idea of, like, oh what it would have been like if I were a child now and I had access to the internet, and like, how good that would be. And then sometimes I wonder, like, whether or not it would make things too easy.

**DANNY HILLIS:** Well, in some sense, we were also lucky that we grew up with the technology of computers.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** So, we got to see it in simple enough form. And, maybe, you know, because I'm older than you, I got to see it in an even simpler form, like, I remember the first, you know, calculator I ever saw in my life or --

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** -- and so, that, in some sense that was an advantage, because we spent years watching it build up from the bottom of kind of a switching elements, and the very simple functions, and the machine language programming.

**KEVIN SCOTT:** Yep.

**DANNY HILLIS:** And then all the layers of software that gradually got put on top of that. And now, I think it would be very tempting just to kind of skip straight to the real --

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** -- powerful functionality and --

**KEVIN SCOTT:** Yep. Yeah, and, like, that's a recurring theme. I mean, it's funny, like, I haven't to, like, we've never had this conversation before, but I've had this chat on this podcast with a bunch of other people, of, like, the same theme emerges over and over again.

And, like, there's, you know, on the one hand, like, all of that complexity and the abstractions that we built over the years to sort of package them up and, the complexity up in ways where you can very easily use it to build things is great. And on the other hand, like, not having that deep fundamental understanding of what's really going on from top to bottom can hinder you sometimes.

**DANNY HILLIS:** Right. both kinds are really useful, because if you, of course, if you try to work from that level, then you miss a lot of the power of building on what other people have done and so on.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** But, I mean, you mentioned, well, you said something about, like, I made some of the first parallel computers, and I was thinking if they really, the audience really knows what it meant to make a computer in those days.

**KEVIN SCOTT:** Well I mean let’s talk about this, like, we'll go back to, you know, sort of MIA let's just go straight there. So, you, you know, you were traveling all over the world, you know, sort of a precociously, curious child, and then you go to college, and it's MIT, right?

**DANNY HILLIS:** Yeah, and actually, I went to college, I really, I mean, the computer thing was cool, but I never thought of it as a career.

**KEVIN SCOTT:** Right. Did they even have a computer science program at MIT when you started?

**DANNY HILLIS:** It was combined with electrical engineering.

**KEVIN SCOTT:** Okay.

**DANNY HILLIS:** But when I went there, I wanted to be a neurophysiologist. I went to study the brain.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** And the brain was obviously the most interesting mystery.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** And it still is.

**KEVIN SCOTT:** Yeah, still is.

**DANNY HILLIS:** Still is, exactly. Actually, I just came from the BrainMind conference.

**KEVIN SCOTT:** Nice.

**DANNY HILLIS:** And the, yeah, so it's still basically a mystery.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** That's how it works. We understand little bits of it, but

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** -- and so, when I went to MIT, I had read this paper that I was very excited about, that they stuck probes inside a frog into the optic nerve, and they had worked out that the signal being sent from the eye to the brain was not just like a pixel. It was actually a pattern. It detected like a black dot against a moving across a light background.

**KEVIN SCOTT:** So, the nerve cells in the eye were encoding information basically.

**DANNY HILLIS:** Exactly. The paper was called “What the Frog's Eye Tells the Frog's Brain” by Jerry Lettvin and a couple of co-authors. And I had read this and I was just so excited, because this is what I want to do, because they're starting to felt like you were just starting to figure out all the neurocircuitry.

And my first day at MIT, they sort of have a party for the incoming freshman. And I go to this party and there was this guy sitting there holding forth with the freshman, so pointing them, what are you interested in? And whatever they were interested in, he would explain to them why it was a crazy thing to study. And so, he gets to me, and he say, you know, what about you? I said, "I want to study neurobiology." And he said, "Oh, that crock of bleep."

**KEVIN SCOTT:** Yep, yep. Oh, and I think I know who this was.

**DANNY HILLIS:** Yep, I'll say, yeah, that's right. So, he completely tore apart, he was like, tell me one good paper that's ever been written. And, of course, he completely tore apart this paper, and, of course, he turned out to the be the author of the paper. And, so, so, but he did sort of convince that that was not the moment to study the brain, that it was, you know, the tools were too crude.

But he suggested that I go over to meet Marvin Minsky, and so, I followed that instruction, which is another story that's kind of fun.

**KEVIN SCOTT:** Yeah. Yeah, you should tell it.

**DANNY HILLIS:** The, so, I had this instruction to go over and find the great Marvin Minsky, who, of course, I had heard of, but --

**KEVIN SCOTT:** And he was legendary at this point.

**DANNY HILLIS:** Oh, totally legendary, and he was the guy that, you know, he and McCarthy had invented the term artificial intelligence.

**KEVIN SCOTT:** Yes. Yeah, the famous Dartmouth workshop in the summer of '55.

**DANNY HILLIS:** Yeah.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** Yeah, and so, and the AI lab in those days was often tech wasn't even on campus. It was in the special building, you had to have special keys to get into. So, of course, I went over there, and I couldn't even get into his office without slipping in behind somebody.

But then I get to his office, and he's not there. And so, I hang out and I manage to get a job in the, I'm trying think, undergraduate research job in the building, still can't find him, he never showed, and I started asking around. They say, oh, no, he's down in the basement. You know, there's this new thing called a microprocessor and he's trying to make it into a personal computer like Alan Kay was doing off in (inaudible).

So, I go down to the basement, and he only comes in at night to do this. So, I go down in the basement and sure enough, you know, there's Marvin surrounded by a bunch of his graduate students, and they have big wire wrapped boards, and they're working on this thing. But I'm so awed by Marvin Minsky that I don't really feel like I can just go up and introduce myself.

So, I sort of hang out and watch the action, and there were some circuit diagrams sitting on the table, and I start looking at these, and I find a mistake in one, and I'm, like, oh, this is my entrée. So, I go up to Marvin, and I say, "Look, you know, there's a mistake in this diagram."

**KEVIN SCOTT:** Do you remember what the mistake was?

**DANNY HILLIS:** It was an inversion of a signal.

**KEVIN SCOTT:** Okay.

**DANNY HILLIS:** It was clocking in a leading edge instead of falling edge.

**KEVIN SCOTT:** Yep.

**DANNY HILLIS:** So, it was an inversion of a clock signal.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** But --

**KEVIN SCOTT:** A good mistake for an 18-year-old to be able to catch, right?

**DANNY HILLIS:** Yeah. Probably 17.

**KEVIN SCOTT:** Seventeen, yeah.

**DANNY HILLIS:** Yeah, because it was when I first arrived, right.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** And, so I go and he says, "Okay, well, fix it." And I'm, like, well, what can I do that, and he's like, "No, no, fix it on the machine, you know, fix it in the diagram and fix it in the machine." So, I did that, and then, so I found another mistake, and I go to him, and he says, "No, no, just fix them when you find them, you know."

And so, after a while, Marvin Minsky just assumed I worked for him, and so that was the start of a very long relationship with Marvin Minsky.

**KEVIN SCOTT:** That's great. And so, Marvin was your PhD advisor, right?

**DANNY HILLIS:** He was, yes.

**KEVIN SCOTT:** Wow.

**DANNY HILLIS:** Well, I had a couple of PhD advisors. I had a team of Marvin Minsky, Claude Shannon, and Gerry Sussman.

**KEVIN SCOTT:** Yeah, it's like the best PhD advisors ever for the dissertation you were writing. I mean, it's incredible. I mean, so, for the audience, like, Marvin Minsky is the father of AI. Claude Shannon is, like, the father of information theory, like, basically the foundation of modern society.

**DANNY HILLIS:** He invented the Bit.

**KEVIN SCOTT:** Yes, he invited the Bit.

**DANNY HILLIS:** Yeah.

**KEVIN SCOTT:** And Gerry Sussman is, like, one of the, like, most incredible computer scientists who ever lived.

**DANNY HILLIS:** Yeah.

**KEVIN SCOTT:** Like I still, like, his intro techs for computer sciences, like this, this --

**DANNY HILLIS:** Oh, it's fantastic.

**KEVIN SCOTT:** -- it's like just a thing of beauty, structure and interpretation of computer programs, right?

**DANNY HILLIS:** Yeah, very good.

**KEVIN SCOTT:** Yeah. Just an incredible book, yeah, obviously, yeah, that was a great, great group of folks. Well, so, and while you're at MIT studying, this is when you founded Thinking Machines, right?

**DANNY HILLIS:** Yeah, which in those days, that was not a normal thing for a student to found a company.

**KEVIN SCOTT:** Still not entirely a normal thing, I mean, especially a super computing company.

**DANNY HILLIS:** Well, yeah, well, it turned into a bigger prob I was trying to do it at MIT and I couldn't hire people because I was a student. So, it --

**KEVIN SCOTT:** So, why do this at all?

**DANNY HILLIS:** Well, so, it was really for artificial intelligence. It was kind of a sidetrack. So, it was very clear that the brain worked much faster than computers did. And it was very clear that if computers were going to be fast enough, they'd have to have an architecture that was more like the brain.

But in those days, the doctrine of computer science was that if you use more than one processor on a problem, it gets less and less efficient as you get more of them. It was called Amdahl's Law.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** If you remember that.

**KEVIN SCOTT:** Oh yeah.

**DANNY HILLIS:** And so, the idea was, well, maybe you can use four or five, but you can't use 50 or 60 or 100. And I knew that that sort of had to be wrong for artificial intelligence because our circuit switch in milliseconds, they were much slower than transistors, and yet, we could recognize a face in a second, or --

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** So, I knew that the brain had a parallel architecture. So, I didn't know then what was wrong with Amdahl's Law, but I decided that to do AI, we needed to build parallel computers, very parallel computers, massively parallel computers. And that was when LSI Technology was coming out and you could make these circuits, they were NMOS circuits in those days, but later became CMOS circuits.

And so, I made, I think, probably the first chips that had multiple processors on a single chip.

**KEVIN SCOTT:** Yep.

**DANNY HILLIS:** And sort of had the basic sort of multi-core idea and that was considered very radical, because how could you use multiple processors on a chip --

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** -- because then I know that was every time I would present this, somebody would raise their hand and say, "Excuse me, haven't you ever heard of Amdahl's Law?"

**KEVIN SCOTT:** Right. But, like, what you doing was, like, let's forget about the fact that you were a graduate student when you were doing, which is, like, one level of incredible. But, like, what you were doing was just sort of provocatively different. Like, the fastest computers in the world at the time were probably the machines that Cray was building.

**KEVIN SCOTT:** And so, they were deeply pipelined, you know, liquid cooled.

**DANNY HILLIS:** Super-fast switches, yeah.

**KEVIN SCOTT:** Super-fast switching, you know, they were liquid cold, because they clocked them as fast as you could possibly clock the, you know, whatever the flavor logic they were using at the time. And, like, they were --

**DANNY HILLIS:** And they were all about, like, making the wires short so that, you know --

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** -- the single processor could operate very quickly.

**KEVIN SCOTT:** And like they weren't, like, I forget exactly what the chronology of things were, but, like, they didn't have, I mean, they never had many processors then.

**DANNY HILLIS:** Yeah, they've had maybe four or eight processors.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** And so, yeah, that was what a super computer was. And I was building this thing, which was actually you didn't do flooding point, first of all. I mean, it was much more of, like, what actually is now, like, a NVIDIA chip or something like that, except it filled a room.

**KEVIN SCOTT:** Yep.

**DANNY HILLIS:** But, it was, and actually, we built two generations. Well, the first generation was actually, literally, like an NVIDIA chip in terms of its architecture.

**KEVIN SCOTT:** Yeah, and that was the CM2?

**DANNY HILLIS:** That was the CM2. The CM1 and CM2.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** That's right. And those were very much, you know, single instruction operating on a lot of data and so on.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** And then, later, we made things that are more like cloud.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** But that came later. But when we did that, the first one had 64,000 processors.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** And that was just like a --

**KEVIN SCOTT:** Radical.

**DANNY HILLIS:** -- I mean, people would think you were joking --

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** when you said that. It was incredible. And I wrote an article for *Scientific America*. I said, you know, it's interesting there will be lots of processors, and it's much better to put them close together than to each other than to people because they talk at higher bandwidth.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** So, we are going to put, like, all the processors, you know, the whole country will run off some big pile of it will be like utility. And *Scientific America* said the --

**KEVIN SCOTT:** Yeah, you predicted the cloud.

**DANNY HILLIS:** -- they said, look, this is just too implausible. You can't say that. And so they said, well, we'll let you say a single city.

**KEVIN SCOTT:** And this was when?

**DANNY HILLIS:** Oh, this was in the early '80s probably.

**KEVIN SCOTT:** Yep.

**DANNY HILLIS:** Yeah. So, they made me talk it down to a whole city will run off this. But that's how implausible it seemed to people, yeah, that. And it wasn't obvious for a while how general purpose it was. So, of course, some of the first people to use it were people like, you know, Geoffrey Hinton, who used it, you know for connectionist things, as it turns and you know, it gave him a few orders of magnitude. As it turned out, he needed a few more orders of magnitude than that.

**KEVIN SCOTT:** Right. And for folks who are listening, Geoffrey Hinton is like more or less the creator of modern deep learning.

**DANNY HILLIS:** So, he was certainly one of the key creators.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** That's right. And he was working on it back in those days, and pretty much the same algorithms that --

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** -- are the ones that have come to work.

**KEVIN SCOTT:** Yeah. And he was compute constrains, like, they were

**DANNY HILLIS:** Yeah.

**KEVIN SCOTT:** -- just very computationally expensive, and, like, nowhere in the world was there enough compute to train a deep, neural network.

**DANNY HILLIS:** Yeah. So indeed, it turned out to be true that the hypothesis that AI wasn't going to make big in roads until it had much more computing, and it did need parallel computing. I think, that's finally turned out to be true.

And, of course, you know, just 64,000 processors in those days at the clock speeds they were at wasn't nearly fast enough.

**KEVIN SCOTT:** Right. Well, and I remember, so I, when I was in graduate school, and this, actually, no, I was in undergraduate, so I was on a National Science Foundation research experiences for undergraduate assistantship at the University of Illinois at the NCSA, and when I got there, they had just installed the biggest CM-5 in the world, the biggest public --

**DANNY HILLIS:** Yep, yeah. And that was probably the fastest computer in the world at the moment it was installed, yeah.

**KEVIN SCOTT:** Oh, it was, it was absolutely the fastest computer in the world.

**DANNY HILLIS:** Yeah.

**KEVIN SCOTT:** And, like, I remember seeing this thing for the first time, and, like, not only was it the fastest computer, it was like this thing of beauty, like this giant, you know, like, sort of, you know, 2001 space odyssey, you know, like black, you know, monoliths with these red, or, you know, matrix of red blinking LED -- it was a fantastically beautiful machine.

**DANNY HILLIS:** It's, well, thank you. It's funny, I just got a picture. Somebody just sent me a picture, the Museum of Modern Art just opened up, and at the entrance way they have a connection machine with the lights flashing.

**KEVIN SCOTT:** That's awesome.

**DANNY HILLIS:** The Museum of Modern Art, yeah.

**KEVIN SCOTT:** And then, you know, like, the funny thing, I, like, I mean, obviously, it wasn't a real connection machine, but there was in Jurassic Park. It was the computer that --

**DANNY HILLIS:** Oh yeah, yeah, that was a lot of fun for us. That's right. You do see it in background scenes.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** But they actually did buy the real shell of one.

**KEVIN SCOTT:** Yeah. And so, for, like, five or six years there your company made the fastest computers in the world.

**DANNY HILLIS:** We did. And, yeah, there was a list, and actually, you had to go quite far down the list before it wasn't one of our machines.

**KEVIN SCOTT:** Yeah. Which is, you know, again, like, for something that you started this company when you were, you know, when you were a student at MIT and, like, it went on to, like, have this, like, lasting mark on the world. And, like, the thing that you and I have chatted about a bunch of times is, like, we're now building a new flavor of super computers to train AI models, like these deep neural networks, and the architecture of the machines that we're building right now is more or less what you built 30 years ago.

**DANNY HILLIS:** Like it's a lot faster.

**KEVIN SCOTT:** A lot faster.

**DANNY HILLIS:** But yeah, it's fundamentally the same architecture.

**KEVIN SCOTT:** Yeah. You had this idea that sort of informed, like --

**DANNY HILLIS:** Yep, and --

**KEVIN SCOTT:** -- three decades of artificial intelligence.

**DANNY HILLIS:** -- and you pretty much programmed them, you know, the way that we programmed is things like MapReduce and so on,

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** That we sort of built into the hardware actually in these days.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** So --

**KEVIN SCOTT:** Yeah, and like, that's, look, that's one of the slightly nicer things now versus then. The frameworks that you code in are, like, so much, so much more powerful, so like you end up, like, writing 1,000 lines of python code.

**DANNY HILLIS:** Oh yeah, that's amazing. And that's the advantage of sort of starting with, you know, the advantage of all the work that's been done, compilers, for example, and things like that.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** I mean, you know, when we built that machine, it was literally, it would take a piece of graph paper and start drawing the shape of the transistors on the chip.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** And then, you'd go all the way and then, you'd have to write an assembler. I've, you know, every time I'd make a new processors and I'd have to write a new assembler for it.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** And then you, you know, and then answer, build it out, that's right, yeah.

**KEVIN SCOTT:** And then build the compilers and the operating system. And it was a Herculean effort. And you had, like, really, really smart people working on this.

**DANNY HILLIS:** Well, actually, that's probably the biggest legacy of Thinking Machines is because the architectures, that style of massively parallel architectures didn't really become mainstream until, you know, really a couple of decades later when, you know, with the cloud and all. Two things, one was the cloud, but it's the sort of multiple instruction root and the single instruction root was with the graphics processors and --

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** But the real legacy, I think was the people. And it just, because you have the fastest machines in the world, it attracted really bright people, who had interesting problems. So, actually, you know, one of my favorite examples was I went out to Cal Tech and asked Richard Feynman, the physicist, if he had any students that, you know, would be interest in, you know, coming to the company. This was when I was very first starting.

And to, you know, spend the summer there, summer interns basically. And he said, "Oh, you know, I've heard about your cooky architecture. You know, it's like, I don't have any, you know, people, Cal Tech students have a lot more sense than that, you know. There's nobody I know that would be crazy enough to come out. He says, he says, "Actually, there is one guy, but he doesn't know anything about computers. Maybe he'd be dumb enough to do it.

And he's hard worker, and actually, I think probably he's your best bet.” And I said, "Okay, well, I'll hire him. What's his name? And he said, Richard Feynman. And so, Dick Feynman was like my first summer hire.

**KEVIN SCOTT:** Yeah, so, look. You have to admit, you had an unusual start up. So, you had, like, Marvin worked for you at some point.

**DANNY HILLIS:** Yes, Marvin and --

**KEVIN SCOTT:** So, you had, you know, father of AI, Turing Award winner.

**DANNY HILLIS:** Yeah.

**KEVIN SCOTT:** You got a Nobel Prize winner --

**DANNY HILLIS:** Well, actually, he wasn't a Nobel Prize winner, well, he was a Nobel Prize winner, but then, we also had Sydney Brenner, who later won a Nobel Prize. We had people come. Eric Lander, who is the, you know, the famous geneticist, and, you know, runs the Broad Institute, and he came, he didn't know anything about biology, but he was like, you know, we're starting a sequence of the Genome, and this is the only computer that's sort of big enough that it'll search for the patters in it, and so on.

And so, he came and, you know, before really he was ever heard of in biology, so it was a really interesting set of people that came out of that, and, you know, went on to, you know, do really interesting things across the industry.

**KEVIN SCOTT:** So, at some point, like, you stopped doing Thinking Machines, and, like, moved on to something else. Like, talk a little bit about, like, how, like, what happened there.

**DANNY HILLIS:** So, well, first of all, I didn't know anything about making a business. So, I made a lot of mistakes in how I set up the business. And at some point we started taking money away from Cray Computer, which had been the most profitable Fortune 500 company when we started, and stopped being so profitable as we started selling these parallel machines.

And so, they got some laws passed that you couldn't export anything more powerful than a Cray. And also, the DOD had to spend any super computer it bought, it had to be op code compatible with.

**KEVIN SCOTT:** Wow.

**DANNY HILLIS:** So, we basically, it all got totally blindsided by that. And because we had sort of managed the company for growth, growth, growth, growth, it was just an exponential curve. When that didn't happen, we ran into a cash crunch. And so, we had to sort of do, you know, Chapter 11 distressed sale. You know, so it went from sort of everything looking great and, you know, very, very quickly went downhill.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** I learned a lot of I mean, if I knew what I knew now, I'd never get a business in that position.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** But I wasn't really thinking about the business, and, so, but it had a happy ending, which was that a lot, the whole hardware side of the company got bought by this workstation company called Sun Microsystems. And so that team went, and I managed to, Sun agreed to give every employee that came a share of Sun Microsystems stock for a share of Thinking Machine stock.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** So, they all did very well.

**KEVIN SCOTT:** Oh, that's great.

**DANNY HILLIS:** And so, it did sort of help make the web happen, and stuff like that.

**KEVIN SCOTT:** And some of those people went on to, like, have very senior roles --

**DANNY HILLIS:** Oh, yeah.

**KEVIN SCOTT:** -- at Sun Microsystems and did very all sort of, like, cool things there.

**DANNY HILLIS:** Yeah. So and part of it went to Oracle and did very well there. So, it was, you know, still a really nice, I'd say alum team.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** And, you know, and also, just among the customers too. I mean, really, if you had taken the people that were the customers, that were, you know, the graduate students that were working on it, they were people like, you know, Sergey Brin --

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** -- were, you know, off, you know, programming connection machines, if you just had a portfolio that was investing in, you know, either, you know, the people that were alumni of Thinking Machines or the people that were customers of Thinking Machines, it would have a great --

**KEVIN SCOTT:** Yeah, that would have been a great portfolio.

**DANNY HILLIS:** It would have been a great portfolio, yeah.

**KEVIN SCOTT:** Yeah. So, you went from Thinking Machines to Disney?

**DANNY HILLIS:** Well, so, you know, so that was a very sad moment for me, because that was, you know, unexpected, things seemed to be going great, and then --

**KEVIN SCOTT:** Yep.

**DANNY HILLIS:** And so, I felt I let everybody down. I felt really terrible about it, and I just said, and my kids were, had just been born. My daughter was actually born on the day that Thinking Machines filed Chapter 11.

**KEVIN SCOTT:** Oh.

**DANNY HILLIS:** And, so, that was tough. So, it's just like, you know, I just want to do something fun for a while that I can relate to my kids on.

**KEVIN SCOTT:** Yep.

**DANNY HILLIS:** And I had a friend Bran Ferren at Disney, and he said, "Why don't you come on out to Disney?" And so, I had always wanted to be an Imagineer since I was kid.

**KEVIN SCOTT:** Yep.

**DANNY HILLIS:** And I got kind of second education there.

**KEVIN SCOTT:** Yep.

**DANNY HILLIS:** So, I thought it was just going to be a lark, but actually I learned a huge amount there.

**KEVIN SCOTT:** Yeah. And I've sort of seen some of the work that you all do now and some of your team, and, like, that time at Disney is really important to what some of the stuff that you're doing now. Right?

**DANNY HILLIS:** Yeah. It definitely is. I mean, one of the things I learned is I mean, before, because I never had a job. So, that was the first thing I learned, so what it looks like being inside a big company.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** And I remember the first time I got a paycheck from Disney and it, like, benefits and I was, like, oh, that's why they're called benefits, because always before those were the things I had to pay, right. But you sort of saw what big companies were really good at.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** And it was so easy for them to do things that were just impossible for a small company to do.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** But it was also very hard for them to do certain things that were easy for a small company to do.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** So, that made me sort of appreciate that there was a need to kind of do interdisciplinary things that companies, even incredibly creative companies like Disney were, you know, it was founded on creativity, that didn't mean they were really good at everything. It meant they were really great at, you know, building a theme park, making a movie.

**KEVIN SCOTT:** Right. And so, what are some of the things that Imagineering did while you were there?

**DANNY HILLIS:** Well, a bunch of things. Well, for example, my favorite project, because I got to see it from clean slate to opening was Animal Kingdom. And that was nice of, you know, what kind of part could we have, and, you know, sitting around blank sheet of paper literally, you know, here's a plot of land, what could we do with it, and all the crazy ideas about what to do with it, and Disney has a great brainstorming process called a (inaudible) for doing that.

And then, going all the way to the day that, you know, opening day where I brought my kids into the park.

**KEVIN SCOTT:** Wow.

**DANNY HILLIS:** And the park, I don't know if you've ever visited all the Disney parks, one of the design principles is there's always something in the center of this, kind of the dramatic orienting thing, like the castle.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** And there's a lot of storytelling reasons for that. But there's something special. And in the Animal Kingdom is this amazing tree with animals growing in the bark and things like that. And it's just an incredible thing. And I go in there with my five-year-old kids or say, and we look and walk in, we look at the tree, and they look up at me and they say, "Daddy, did you make that or did God?" I was like, okay, this is like the peak dad experience.

**KEVIN SCOTT:** That is pretty good. So, and you were working with computer scientists, engineers, artists.

**DANNY HILLIS:** Well, all the different kinds of people, and what I thought of as an interdisciplinary team before I went to Disney, my idea of interdisciplinary got broadened out. One thing that Disney is really great about, and actually Hollywood is really great about, is they have kind of a different way of doing big projects, as usual in tech, which is the studio model.

So, let's say Disney makes a movie. Actually, there are some Disney employees that make the movie, but mostly it is a set of people that, you know, Disney knows a great director, knows a great actor, knows a great screenwriter, and so they pull those things together, and a lot of people who are used to working with each other have roles. And they've worked with each other on multiple projects in different combinations.

And I realized that was really kind of a very efficient way to do innovation. It wasn't, I mean, and also having seen the sort of downside of, you know, what the difficulty of being a small company where, you know, you have to get a lot of things exactly right for it to work, some of which had nothing to do with the product or the customers or things like that.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** And so, it was sort of nice that to sort of see a different way of doing things and see how quick and efficient and how much energy it could get out of people and so on. And I thought, wouldn't it be great to do technology projects like that where you had a core of people that kind of knew how to do projects together that were kind of the producer, director types, you know, they have the concept. And then you had a big pool of a network of people that were really good at doing things that you could bring on when you needed them, and that that was a really good way to build technology systems.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** So, that's what I ended up leaving Disney with Bran Ferren, the guy that I went there with, and we started a company basically to do that kind of project where we would quickly build a system on that kind of studio model.

**KEVIN SCOTT:** Right. And that was Applied Minds.

**DANNY HILLIS:** That was Applied Minds. And then --

**KEVIN SCOTT:** And then the company you're running now is called Applied Inventions.

**DANNY HILLIS:** Yeah, which I've evolved from Applied Minds. And Applied Minds ended up doing two kinds of things, one of which was kind of commercial things that turned into commercial products. And the other thing was it started doing things for the government that aerospace companies, things like that.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** And those had kind of a different rhythm to it. And over time, I was more interested in the kind of commercial things.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** Bran was more interested in the more kind of aerospace projects, those kinds of projects. So, we ended up doing two different kindsof things, but kind of handicapping each other a little bit, because the processes were different for those things.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** So, eventually, I went to Bran, and I said, "Look, Bran, let's either stop the government work, because it has all these regulations and things like that, or let's split the company."

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** And Bran was like I don't want to stop the government work. I'm loving it. And so, we split it up, and, you know, still good friends.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** But I took part of the company off, and just concentrated on the commercial work.

**KEVIN SCOTT:** And it's really interesting commercial work.

**DANNY HILLIS:** It is so fun. It's all looking for things where somebody has an idea of something that's going to change the world somehow. They don't have all the elements to do it, but they have some vision or and, so that's a commercial partner.

And then, we go in and we team up with them almost like we're their skunk works, as if we work for them.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** And we work with them to build up that new product or line of business or something like that.

**KEVIN SCOTT:** And your team's still fairly multi-disciplinary. You have physicists. You have chemists. You have mechanical engineers. You have computer scientists. You have electrical engineers. You have firmware people. It's --

**DANNY HILLIS:** Yeah, people are, like, well, I don't get it. How are you going to have a team that builds a satellite and a blood test?

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** I mean, it's -- but --

**KEVIN SCOTT:** And like robots that explode bombs for police forces.

**DANNY HILLIS:** Yeah, yeah.

**KEVIN SCOTT:** And, like, the 10,000-year clock, which we're going to talk about in a minute. It's incredible.

**DANNY HILLIS:** Yeah. And, well, part of it, what makes it work, is that network of people out there who have deep knowledge in particular things, like, you know, we needed a fish psychologist. We didn't have a fish psychologist on staff, but we knew one.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** Right.

**KEVIN SCOTT:** Which is, yeah, I didn't even know, I didn't know such a thing existed before I knew you, fish psychologist.

**DANNY HILLIS:** But there is a kind of expertise that's the systems building. And at the core of it, of course, everything is computers too.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** And so, at the core of everything we do, there's some sort of big data. So, the parallel processing theme is still kind of there.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** Of course, machine learning is now a tool they use in almost everything. So, AI, you know, it's still a part of the thread in it.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** Although we usually don't call it AI. We just can, you know, you use, you use machine learning and things like that as a double plot.

**KEVIN SCOTT:** Yeah. I mean, I'm sort of interested in that. I mean, like, machine learning is obviously the more technically accurate label for, like, what most people doing AI are doing right now, like, it's very particular thing. It's like you have large volumes of data, and, like, you're building some sort of, you know, quayside statistical model to, like, extract patterns from the data that let you do classification and inference and whatnot.

**DANNY HILLIS:** Right. And they're doing it because it's working really well in my work --

**KEVIN SCOTT:** And it works really well.

**DANNY HILLIS:** -- with the powerful machines that we have.

**KEVIN SCOTT:** Yeah. But, so, you also have been doing this long enough where you actually know what an AI winter is, and, you know, so, like, we've been through a few hype cycles. Like, what's your perspective on that right now?

**DANNY HILLIS:** So, I think intelligence is a many splendored thing. There's lots of components to it. There's lots of aspects to it. And I think it's happened before that we find some aspect of it that's a building block of it, and it's important and useful, and that becomes AI, because we suddenly make progress in it.

So, right now, it is machine learning, pattern recognition, and it's an incredibly powerful building block, and there's still lots of great things to be done with it, and, you know, we use it in everything. So, I'm a big fan of that.

But there's still lots of things that a human mind does that don't fit into that paradigm. So, what happens in the past is that when you make up the explosion, everybody starts talking about AI as taking over the world and this happened with machine vision, it happened with speech recognition, it happened when they, AI is, you know, planning where you can play AIs would beat humans at chess.

And then, what happens is people say, okay, well, that thing, now we understand what that thing is, but that's not AI. And so, you just start using that thing as a tool. And so, I suspect that's what will happen with this current thing is people will realize there's more to general artificial intelligence than these multilayer neural networks.

And, of course, you know, there are many people who do realize that. And so, we'll, you know, run into the next set of hard problems while people still continue to apply these multi-level neural networks to very important problems. I mean, I don't --

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** -- want to trivialize how much good they're going to do.

**KEVIN SCOTT:** Yeah. But in a certain sense, like, the AI boom bust cycle is just like any other boom bust cycle where the both extreme ends of the cycle are not helpful.

**DANNY HILLIS:** Right.

**KEVIN SCOTT:** Like the overhype, like where you get reckless with investment and you, like, have a whole bunch of people who, like, reallymisunderstand what's going on and are sort of, you know, making these, you know, leaps of faith basically about what is coming next, yeah.

**DANNY HILLIS:** But both positive and negative.

**KEVIN SCOTT:** Correct. But both positive and negative.

**DANNY HILLIS:** Yep.

**KEVIN SCOTT:** Which is, like, I think really important.

**DANNY HILLIS:** Yeah.

**KEVIN SCOTT:** Like, oh, you know, like, AI is going to be this apocalyptically bad thing, or it's going to be this, like, you know, sort of unrestrained eutopia. Like both of those extremes are like bad things to infer from where we're at. But, and the bust cycle, you know, so, like that heats up, and then, you know, the bubble pops, and, you know, everyone's in sort of the dull drums of, you know, the aftermath of this whole thing, and, like, that's also not helpful.

**DANNY HILLIS:** Right. Because a bunch of people --

**KEVIN SCOTT:** But there's a bunch of -- yeah.

**DANNY HILLIS:** Yeah, it gets underfunded and it's very hard to get good ideas to getting attraction, and so on, and so.

**KEVIN SCOTT:** Yeah, I sort of feel like we'd be maybe, you know, five or ten years ahead of where we are right now if we had just been able to mediate some of the boom and bust over the past four decades.

**DANNY HILLIS:** Yeah. I think that's probably right. And it's probably trivial technology is in general. Part of it happens too with, you know, a lot of what determines the usefulness of technology is people, and people's ability to adapt to it and so on. So, I think part of what causes that cycle is technology grows very quickly, and then so, it gets ahead of people's ability to use it, and society's ability to adapt to it, and then it sort of feels like it's not working, and it feels like it's bad. And then you sort of have a reaction to it like we're going with social media right now.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** And, you know, social media is, you know, was never the, by itself, the thing that was going to, you know, advance humanity, nor is it the thing that's going to destroy humanity is actually a tool that we're going to learn to use with time like we learn to use fire.

**KEVIN SCOTT:** Yep, yep.

**DANNY HILLIS:** And, and so, it's, you know, it takes us a while to work those things out. And sometimes it takes longer to work out the societal response to something that it does to actually develop the technology.

**KEVIN SCOTT:** Yeah. I mean, the thing that I tell technology folks about AI all the time is AI is not a product. It is a, like it's a feature, it's a technique. Like machine learning is, I mean, just exactly what you said. It's such a useful technique right now that every maker, like, whether you're a computer scientist or another flavor of engineer or scientist or, like, someone who's trying to create something with technology, like, it ought to be a thing that's in your bag of tricks --

**DANNY HILLIS:** Exactly.

**KEVIN SCOTT:** -- that you can use to help you solve your problem.

**DANNY HILLIS:** Yep.

**KEVIN SCOTT:** And it's a very, very powerful tool, but it's not magic.

**DANNY HILLIS:** Yeah, that's right. And then --

**KEVIN SCOTT:** Anymore than hash table is magic.

**DANNY HILLIS:** Yep, yep, yep, that's right. Well, and hash table actually is kind of magic, but --

**KEVIN SCOTT:** Yeah, it is, in a way.

**DANNY HILLIS:** But that's, but yeah, and, I think, you know, again, say so, we've seen waves of that. This is the one we're going through now, and everybody should learn about it. Everybody should learn how to use it.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** And I'm not against worrying about the implications of things, you know, I mean, looking at things like, you know, what happens when you have the ability to recognize everybody's faces. How does that affect, you know, how does that affect government's ability to control us citizens?

**KEVIN SCOTT:** Yep.

**DANNY HILLIS:** How does it affect, you know, those are things we really should be working about. And those things will take longer than developing the face recognition.

**KEVIN SCOTT:** Correct. Yeah. I mean, the thing that I think we need to be doing more of is we need to be having more robust public debate about the pros and cons of these things. Like, I'm personally uncomfortable in a world where the technologists make policy by virtue of the things that we're building, you know, sort of policy is better made by, like, policy makers with the input of the public in a democracy.

And, like, you have to have everybody sort of playing their part and contributing.

**DANNY HILLIS:** Yeah. It's also very hard to do as far as hard to guess what the issues are going to be.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** You know, certainly, the first time I saw Twitter, I didn't think, oh, well, let's think about the affect this is going to have on the political system.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** I mean, just never occurred to me.

**KEVIN SCOTT:** It never -- me either.

**DANNY HILLIS:** And, you know, and now I can look back and say, well, actually, this had a very big effect, and, you know, I think we really need to think about that.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** And we need to -- but it's hard to see. So, even if there had been -- if somebody had asked that question, which I didn't, but if somebody had, it's not clear to me that they would have been able to think through all of the implications --

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** -- and the kinds of emergent behavior that happened.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** And ultimately, I do believe that these technologies are going to create a kind of emergent behavior in society that's good.

**KEVIN SCOTT:** Yes.

**DANNY HILLIS:** Because I think that's a trend in evolution.

**KEVIN SCOTT:** It is.

**DANNY HILLIS:** That things cooperate and they do better things as they cooperate.

**KEVIN SCOTT:** Well, and like, the overwhelming trend with human use of technology for the past few hundred thousand years has been positive. Like, you know, in a certain sense, like, you could assert, like, I think fairly, trivially that, like, human, like, we couldn't even support the population of human beings that we have right now without just the technology that we've developed over the past 50 years.

**DANNY HILLIS:** It's clear things are getting better.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** And, you know, and I would say not just getting physically better, but also morally better.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** I mean, you know, the world is a nicer place than it was when I was a kid.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** And, you know, there are a lot of things that were just accepted that we would no longer accept right now.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** About how women were treated, about racial segregation was the norm in the south, when I lived in the south.

**KEVIN SCOTT:** Yep.

**DANNY HILLIS:** And my parents, I remember my parents told me well, this is wrong, but there's nothing you can do about it. Well, it turns out, you know, there was things to do about it.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** And, you know, it's things that are --

**KEVIN SCOTT:** In some of the tools --

**DANNY HILLIS:** Yeah.

**KEVIN SCOTT:** -- like these social media tools that are causing problems right now, like, actually in places have been helpful for remedying some of these, like, issues of injustice.

**DANNY HILLIS:** Yeah. And they've helped, and they've also created injustices sometimes.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** You know, we've had, you know, people literally have been killed because of, you know, runaway memes that have happened on social media and things like that.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** So, we'll learn how to use them, but I think you're right. The general trend for technology is not that it makes everything better every time. But it's certainly more steps forward than it is steps backwards.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** And that has been trend really probably since fire right?

**KEVIN SCOTT:** Right. That is exactly what I was thinking when I said 300,000 years. So, we probably had fire longer than that.

**DANNY HILLIS:** Yeah.

**KEVIN SCOTT:** But, like, you know, it's fire. It's agriculture. It's, yeah.

**DANNY HILLIS:** But I'm sure a few people got burned on that one, right.

**KEVIN SCOTT:** Of course.

**DANNY HILLIS:** Early on.

**KEVIN SCOTT:** Yeah, indeed. And, yeah, so it's not that it is monotonically positive, like, not every step is positive, but, like --

**DANNY HILLIS:** Well, it's positive because we willfully and thoughtfully make it into the positive.

**KEVIN SCOTT:** Yes.

**DANNY HILLIS:** And I think that that's the process that you're talking about --

**KEVIN SCOTT:** Yep.

**DANNY HILLIS:** -- is you can't just say well, we'll make the technology and it will automatically be positive.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** It's positive because, you know, we discuss it, we think about it, we think about how to use it.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** And fortunately, you know, there's more people that are trying to make the world better than trying to make the world worse.

**KEVIN SCOTT:** Yeah. So, one of the more interesting multidisciplinary things that you've done, like, that I'm just sort of personally fascinated by is this 10,000-year clock. Can you tell us a little bit about that project?

**DANNY HILLIS:** So, that actually has its genesis back when I was making the fastest machines in the world, and all my customers were coming to me and saying can't you make it faster, faster, you know, instead of nanoseconds, can you go to femtoseconds?

And I was like, oh, I'm so tired of making everything faster, faster, faster. You know, I really want to make something slower. I mean, it's sort of a -- in my mind it was kind of a joke. But then I heard this story about New College Oxford, which it's called New College because it's only 500 years old or something like that.

They were replacing the oak beams in the New College common room, and you couldn't just go down to the lumberyard and buy a 50-foot oak beam in the, you know, by the time they did it, well, this is in the 1950s.

**KEVIN SCOTT:** Right, because there weren't trees big enough anymore.

**DANNY HILLIS:** Yeah. That's right. But Oxford had some forests, so they went to the Oxford forester and said, "Do you have any oak trees that we could harvest?" And the forester said, "Yeah, we have the ones that were planted to replace the beams in New College."

**KEVIN SCOTT:** Wow.

**DANNY HILLIS:** And when I heard that story --

**KEVIN SCOTT:** Wow. That's planning.

**DANNY HILLIS:** Yeah. Well, it's also, I realized how small my life had become. And then I started thinking about it, and this was, like, in the 1990s when I was thinking this. And I realized, when I was a kid growing up in, you know, the '70s, we were thinking about the year 2000. And here it was the 1990s and the future was still like the year 2000. So, it was as if the future had been shrinking by one year per year for my whole life.

And I wanted to do something that, you know, stretched out my imagination more. I had always loved reading science fiction, things like that, and I wanted to be involved in a project that let me put my mind forward into the future more. And so, I started thinking, because I'm an engineer, about, you know, building something. And, so I started thinking of building a clock, because I wanted to be built out of technology that I knew would last and people could maintain over a long period of time and so on.

And when I started talking to friends about it, I found that it was kind of almost like Rorschach test for them. If I talked to a musician friend like Brian Eno, he would, like, whoa, you know, what kinds of sounds is it going to make, or I talked to a lawyer friend, like, well, how do you write the contract for, you know, the land or --

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** -- you know. And so, everybody would start thinking about whatever it was they thought about, but on a different time scale.

**KEVIN SCOTT:** That's super interesting.

**DANNY HILLIS:** And, yeah, and so I was getting excited about that, and then Stewart Brand, who is this totally remarkable hero of mine, said, "You know, this is making everybody think about things differently. We should start a foundation to think about things like that." And so, that was the origin of the Long Now Foundation, which actually, Brian Eno gave the name to.

And, so, I've been working on building that clock ever since then we've built several versions of it. We started, you know, the first version is in the London Science Museum. The next version you can see actually in San Francisco, that orrery thing at the Long Now headquarters.

**KEVIN SCOTT:** Yep.

**DANNY HILLIS:** And then, now, we're building the real one that will last for 10,000 years in a mountain in Texas.

**KEVIN SCOTT:** Yeah. And so, describe this thing a little bit. So, like, you have a mountain in Texas. You have drilled a shaft at what's the diameter of the shaft?

**DANNY HILLIS:** So, it's a 12-foot diameter shaft. It's about 500 feet deep. The reason for all of this is you can't build a building that will last 10,000 years.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** So, you have to put it in the middle of a mountain.

**KEVIN SCOTT:** And like not just any mountain. Like, you had to select the mountain to be, like, geologically stable.

**DANNY HILLIS:** That's right. And so, there was years of exploring around searching for a mountain. And, fortunately, I found one that was on property that was owned by Jeff Bezos, who was a big supporter of the foundation. And so, he was, like, okay, we've got to do this, and so he's the primary funder of constructing the clock in the mountain.

But even to make a 500-foot shaft is not as easy as you think. What you have to do is you actually have to dig to the bottom of the shaft with dynamite, and then you drill a hole, a little, small hole with an oil well kind of hole, and then you put this giant reamer on it and pull it up through the mountain.

**KEVIN SCOTT:** Yeah, and none of this, like, virtually none of this is, like, off-the-shelf components.

**DANNY HILLIS:** Well, yeah, some of that is -- what's not off the shelf is if you want a spiral staircase cut into the rock around the shelf, then you have to build a custom robot to do that. Fortunately --

**KEVIN SCOTT:** Which you did.

**DANNY HILLIS:** Yeah. Fortunately, I did conveniently have this company around that was good at doing stuff like that. So, but, so we built a robot that climbed up the shaft with a diamond saw cutting a spiral staircase into it. And, I mean, if you look on the Long Now Foundation's website, you can see movies of this. So, it's been a couple of years building the spiral staircase, and then we put into it years, including like, you know, giant bells and the chimes that will ring a different sequence of bells every day for 10,000 years.

**KEVIN SCOTT:** And just the mechanical engineering on this thing is absolutely incredible, because, I mean, you had to cycle test all of thesethings to make sure that they were going to be able to, like, do their job over 10,000 years, right.

**DANNY HILLIS:** Yeah, actually, that was a funny thing. What we learned was that actually, most of the things that we tested worked fine the first time. But we had to repair the machines that tested them about 10 times to make that. It's actually very hard to make a machine that tests 10,000 years' worth of cycles without the machine breaking.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** So, yeah, pretty much everything that we've had that, you know, moves or we've tested it for 10,000 years' worth of motion.

**KEVIN SCOTT:** And there's sort of some incredible things in there, like, you have one of the -- you have a mechanism in there that is, like involves a gigantic quartz lens.

**DANNY HILLIS:** Yes. That's the photocell. How do you make a mechanical photocell? And the answer is that you, first of all you build like a meter-wide quartz lens, and it shines light onto a box, which when it heats up it expands, and that expansion is what triggers it.

And the reason you need that is because you need something to adjust the clock to keep it on time. If nobody visits it for a thousand years or something, the way that it adjusts itself is that it -- during the summer, the summer solstice, the light shines down the shaft, focuses with that quartz lens.

**KEVIN SCOTT:** Yeah.

**DANNY HILLIS:** Causes the thing to expand, and then that adjusts the clock.

**KEVIN SCOTT:** Yeah, and, like, this, I mean, to me it sounds almost like something from a, like, Indiana Jones or a Tomb Raider movie that, you know, like, some future civilization is going to discover this, and, like it's going to be like an archeology project to figure out, like, why this thing is there doing what it's doing.

**DANNY HILLIS:** Well, that is also a lot of what I was thinking about when I was designing it is what would it be like to find this after a thousand years of, you know, it being lost or undiscovered.

And actually, the fun thing was that I realized that you'd really like to know how long it had been undiscovered. So, one of the interesting things about it is that when you go up to the clock, it initially reads the time the lastperson was there. And then, you wind it. So, it knows what time it is, but it doesn't tell you until you wind it.

**KEVIN SCOTT:** Oh.

**DANNY HILLIS:** And then, when you wind it, it moves the dates forward and it moves the astronomical display of the sun and the moons and the stars forward until it gets to the current time, the current date. Then, everything stops and now you've reached that it's when the next person comes, they'll see when you wound it.

**KEVIN SCOTT:** So, you're even thinking about the gamification of, like, how you get the clock wound.

**DANNY HILLIS:** Well it's --

**KEVIN SCOTT:** That's awesome.

**DANNY HILLIS:** --it's definitely, or the storification or, you know, that's one of the things I really learned at Disney is how important, well, first of all, the hardest part of building a 10,000-year clock is that people have to care about it. Because if they don't care about it, then they'll just salvage it from metal or something like that.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** So, that's the hardest design problem. And I think I learned things at Disney that helped me with that design problem in the same way I kind of learned stuff at MIT that helped me with the material science problems and things like that.

**KEVIN SCOTT:** Right. Yeah, but I am just sort of fascinated by the, you know, the breath of your curiosity and expertise, because for many people, like, you would go, like a PhD and a thing, and like that would be your area of expertise, and like, you know, the way that you achieve impact in the world is, like, you know, getting deeper and, you know, more focused on this thing.

And, like, you know, like, we have these crazy broad conversations about things like --

**DANNY HILLIS:** Well, I was incredibly fortunate in the mentors that I had. I mean, if you just think of people like Marvin Minsky, Claude Shannon, Richard Feynman, those were all people like that. They were people that had curiosity and so, you know, I was just lucky to have had them as an example of a, sort of a different way of approaching the world. And so, it's just, you know, I have a lot of fun every day, I have to say.

**KEVIN SCOTT:** So, so we're almost --

**DANNY HILLIS:** But let's face it. We're both really lucky to be alive at this time.

**KEVIN SCOTT:** Yes.

**DANNY HILLIS:** Because probably, they would have burned us at the stake or something, and during a lot of times in history, so.

**KEVIN SCOTT:** Yeah. They probably would, it is one of the things that I'm very grateful for about modern society is, like, society is not just tolerant of curious people, but, like, actually encourages it, and I hope we never lose that.

**DANNY HILLIS:** Yeah, and that's not a normal thing in history, actually.

**KEVIN SCOTT:** Yeah. It is not.

**DANNY HILLIS:** Yeah.

**KEVIN SCOTT:** And, like, you can go read plenty about how curious people were persecuted in the past. So, hopefully not something we lose anytime soon. So, we're almost out of time, and like I always ask people, you know, what they do outside of work for fun, it may be a peculiar question to ask you, because I think you've structured your life brilliantly where you have fun in, like, all of the work that you do.

**DANNY HILLIS:** Yeah.

**KEVIN SCOTT:** But, like, what do you do outside of --

**DANNY HILLIS:** Well, let's see. I mean, really, I have to say that there is kind of a blend of fun and work for me. But I do some things that I have no excuse for doing at all at work, like, I make perfume.

**KEVIN SCOTT:** Oh, I didn't know that.

**DANNY HILLIS:** And I do that really just because it uses a different part of my brain than everything else I do, because I tend to be an overthinker, very logical in my thinking. You can't illogical about perfume. You can't even really give names to the --

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** So, it's the sort of a meditative thing for me, because it turns off what a neurophysiologist would call my default mode network.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** Right.

**KEVIN SCOTT:** Right.

**DANNY HILLIS:** And so, my default mode is very analytical, but in that you really just have to be experiential. So, I look for excuses to do that, hanging out in nature, those sorts of things to compliment it.

**KEVIN SCOTT:** Yeah. That's super cool. Well, this was great. Every time I talk to you, I learn something new. Thank you so much for being on the podcast today.

**DANNY HILLIS:** Well, this is a pleasure being interviewed by a like mind.

**KEVIN SCOTT:** Awesome.

[MUSIC]

**CHRISTINA WARREN:** So, that was Kevin Scott chatting with Danny Hillis.

Kevin, that conversation was incredible. I would love to just like -- I would love to watch a Netflix show about Danny and about Danny's brain, you know?

**KEVIN SCOTT:** Yes, for sure. And like I always have a great time chatting with Danny. I've known him for a couple years now.

And, you know, I think the thing that always strikes me about Danny is just this mindset that he has that I think is a big part of what's allowed him to do the things that he's done.

So, like part of that mindset is he I think just sort of assumes that a problem is solvable until like he's got some pretty serious proof that is isn't, which lets him just dive into things and persist, and like you can sort of see it even in this tic-tac-toe machine that he created when he was a kid.

**CHRISTINA WARREN:** Yeah. No, I love that story so much, and it was so funny, because listening to that, you totally can see how a kid who's in India, who is taking books of the shelf and figuring out how to build this machine, how that person goes on to be an adult who's working at Disney and running the Imagineering stuff, and is, you know, building all these machines and making all these inventions. Like it completely makes sense.

**KEVIN SCOTT:** Yeah, no, I mean, the art totally makes sense, but like you really do have to appreciate like what an unusual set of circumstances thatwas. So, this is Kolkata, like I think in the 1960s, so before the personal computing revolution had even begun to start. And, you know, he's just sort of figuring this out on his own without mentors.

But like, you know, I think in the conversation when we pressed him, like you know, he has this sort of humility about what he did.

And so, granted, like he's an incredibly smart person, but like the thing that's really important I think for all of us to understand is that he had a whole bunch of failed attempts at building this thing before he got the successful thing. And like that mindset and ability to like not only jump into a problem in the first place but then to persist through even when you fail a bunch of times at trying to get to the solution, like that is an incredibly important part about being a really effective creator or even entrepreneur.

**CHRISTINA WARREN:** Without a doubt, because realistically, you know, you're going to fail, there are going to be things that don't work out, and I think it's really inspiring to see someone who's been so successful and has done all these amazing things and is so smart admit, oh, I've had to, you know, try a bunch of times, I've had to figure things out, it hasn't just been super easy, because sometimes the myth is just, oh, you know, it was just, you know, I'd snap my fingers and it was done.

And to know that it took persistence and creativity to think about how to solve problems differently and to try and try and try again is really inspiring.

**KEVIN SCOTT:** Yeah, and I think this is one of the things that people who aren't in the day-to-day grind of creating technology, engineering new things, like doing science, sometimes don't get to see.

So, like what you see is like the end thing that pops out after we've been successful, and the reality is even for like incredibly brilliant people, you have more failures than you do successes on your way to that success.

**CHRISTINA WARREN:** There's this great episode of the Simpsons where Homer is obsessed with Thomas Edison.

**KEVIN SCOTT:** Yeah.

**CHRISTINA WARREN:** And he's trying to come up with his own inventions. And when he goes to the Thomas Edison museum, he finds a list of Thomas Edison comparing himself to Leonardo da Vinci, and he suddenly feels better about himself that he didn't, you know, achieve what Edison had.

**KEVIN SCOTT:** Yeah.

**CHRISTINA WARREN:** I think that's a good thing to kind of put into perspective, that there's a lot of failures and there's a lot of attempts that, as you said, you know, we don't always see when we see the final product but is part of the process of creating things.

**KEVIN SCOTT:** Yes, indeed. And so, like for everyone listening to the podcast like that's just more encouragement for you all to like go out and like try and try and try again, because like ultimately that's the only way that anyone ever gets to like something new and interesting and successful.

**CHRISTINA WARREN:** Absolutely.

All right, well, we are about out of time. As always, we would love to hear from you at BehindtheTech@microsoft.com. So, tell us what's on your mind, maybe tell us about some of the various tech innovations that you're excited about, maybe tell us about some of the ways that you've tried to do something, maybe you failed, maybe you've succeeded. Tell us about your tech heroes and maybe we will invite them on the show.

And, of course be sure to tell your friends and colleagues about the show. Thanks for listening.

**KEVIN SCOTT:** See you next time.

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