Patrick Fine: Hi, I'm Patrick Fine, CEO of FHI 360, and I'm happy to welcome you to the Deeper Look podcast. Today, I've got the great pleasure of speaking with Alex Dehgan on the topic of exponential technologies. Alex, when we first met, it was around a conversation about exponential technologies. That was about, what, a year and a half ago? And since then, if anything, exponential technologies have become more important, more prevalent, more proximate to the work we do in human development. Thank you so much for joining me today.

Alex Dehgan: You can only say this, technologies have become exponential.

Patrick Fine: They're growing at an exponential rate.

Alex Dehgan: And thank you very much. I'm super excited to be here.

Patrick Fine: Alex is the CEO and Co-founder of Conservation X Labs. It's a startup for tech innovation for conservation and development. So, I'm guessing that you use exponential technologies in the work that you're doing at Conservation X Labs. Before starting up this tech startup, Dr. Dehgan served as the Chief Scientist at USAID, where he set up the global innovation lab — it's on the forefront of innovation in bringing technology to bear on international development and human development problems. Prior to that, he was at the Department of State, where he worked in the Secretary's office on a variety of challenging foreign policy issues, primarily in the Middle East.

So, Alex, it seems like technology and innovation are in your blood. You're a scientist. You have a conservation background. Can you just tell me, what do you mean when you're talking about exponential technologies? What are exponential technologies?

Alex Dehgan: That is a really great question. And, for me, the definition is those technologies that are increasing in power efficacy at an exponential rate and decreasing in cost almost at such an equal rate. So, examples of that I think are processing power and Moore's Law, which was saying that chips are doubling in processing capabilities, the number of transistors on a chip were increasing every 18 months. What's even more incredible is that we've now seen this merger of technology and biology. And in fact, our

ability to understand and even harness the human genome is increasing at a rate that's even faster than that of computer chips. If we think of the Human Genome Project, which was started in 1990, ended in 2003, cost $2.7 billion and thousands of scientists working together to sequence one single composite genome. So, the genome of a single individual or a single entity. That can be done today for less than $1,000 in four hours by a single guy or a woman working at a machine.

Patrick Fine: Yeah, that is an exponential difference.

Alex Dehgan: That is an exponential difference.

Patrick Fine: You mention Moore's Law. So, that law that says every 18 months, the processing capability or power doubles. And I just heard last week that Moore's Law has been validated for about 20 years. So, for about 20 years, it's every 18 months or so the processing power does double, and you see this incredible expansion in technology in our lives to now, it's not just the internet, it's the internet of things. And it has transformed our lives. But I heard last week a question about whether Moore's technology had reached its end life, whether it was going to continue to hold true. Have you heard about that?

Alex Dehgan: Well, your limiting factor on computer chips has been heat.

So, you know, part of it is how you deal with your limiting constraints at every step along the way. So, dissipation of heat and how you actually work with heat, that then becomes your limiting factor. But, the advances we're making in nanotechnology, the advances we're making in materials and engineering components and literally creating molecular computers. We're creating DNA-based computers. We're seeing breakthroughs in this area that I don't think that is a constraint. And the great example is going back to what I mentioned earlier, the Human Genome [Project].

When they were halfway through, they had done 1 percent of the genome. And they're like, this was a foolhardy measure. The technology that exists, it's going to take us 100 years and billions of dollars to sequence this. And that's the actual thing: It's hard to actually understand those curves and what those increases mean, right?

Whether you're talking about population growth or you're talking about technological power or increases in cost, it is hard for the human mind to actually fathom. What I think is interesting now is that certain technologies are actually helping us open up entire new other fields, which themselves are growing exponentially. It's not just processing power. It is memory, and it is storage space, and it is communications and it is all these other aspects. Storage space has become so ubiquitous, and the cost has become so little, that companies give it to you away for free – your Google drive, your Flickr sites, Amazon drives. You know, wherever you are storing things in the cloud, you can get those things for free because the costs have gone down so far and the processing power. Compare it to what we put on Voyager when it went out into space.

Patrick Fine: Think when we first started buying PCs: A big part of the cost was the storage space.

Alex Dehgan: A huge part of it, and this will date me, I remember using tapes, like cassette tapes to record programs that I had written myself, and it's just ridiculous to think of what we have done. And then you've got this other process, right? So, we have connected all these computers. You talk about the internet of things, but we have connected all of these computers. And these computers are essentially themselves a large network computer. It is the largest collection of data our species has ever had. And every year, we double that.

In a single year, we generate [as much data as] what has taken us all of the rest of human history to actually generate. The question is, how do we put this to use for good? Technology seems scary. We have the ability now of a new tool called CRISPR-Cas9 and synthetic biology to edit the genome like we edit a Microsoft Word document. And the question is, what do we do with that? Do we get rid of disease? Can we take out invasive species? Or do we use it for other purposes that we may be less happy with? Is there going to be a technological race in terms of editing intelligence or editing physical attributes of people? Technology itself is neutral. It is our value systems and how we regulate that and how we deal with it.

Patrick Fine: If you read the work that's being done by the advocates of technology, particularly these exponential technologies — so, new technologies like artificial intelligence, nanotechnology, some of the advances in agriculture, like aeroculture — the advocates often present the benefits of this technology without any acknowledgement of potential downsides. In other

words, they present it as not that it's a neutral thing, but that it is a beneficial phenomenon. When I have regarded it, I've thought, as you said, that technology is neutral, and it will be used however humans use it.

Alex Dehgan: Yeah.

Patrick Fine: It is not inherently good. It is not inherently bad. It is a neutral thing that humans then will use for good or bad.

Alex Dehgan: I think it's spot on, and I'll talk about something I think is a little bit controversial, which is small-scale farmers. So, I think 50 percent of the farmers in the developing world, or more, are small-scale farmers. And the question is, are they the best unit for actually meeting these incredible needs we have for food security? Are they the best individuals to deal with the incredible challenges of climate change? Are they the best individuals for being able to help with export crops and economic growth within the country and reducing the rates of post-harvest loss and a whole host of other questions, right?

We have this idealized version of small-scale farmers, just like we have an idealized version of wilderness that we think of, this utopia, when in fact almost every part of this earth has had our fingerprints all over it. I've been to this place called the Eurasian Pole of Inaccessibility when I was setting up a national park in Afghanistan. And literally, you are days out from anywhere, and there are sheep and sheep trailings throughout the habitat.

But the small-scale farmer one is like if we're trying to feed 9.8 billion people by 2050, which is 70 percent more food, right, because it's also accounting for all those people emerging in the middle class who want meat and dairy and air conditioning in cars. And that's a doubling of nitrogen, phosphorous, pesticides, water. That area is equal to the United States. And it literally means clearing the Congo basin and the Amazon. That is the challenge.

Patrick Fine: So, your question is, are small holder [farmers] the best way to organize production in order to meet those needs?

Alex Dehgan: What I'm going to argue is that the reason governments may like smallholder farms is because those smallholders may cause political problems when they move into the cities.

So, it may be a political reason rather than an actual economic reason or other reasons that we want people to do smallholder farms. When in fact, if we think about it, it's going to be the use of technology, mechanization, larger-scale farming, improved techniques, improved seeds, improved irrigation approaches that are going to be more resilient, that are going to be actually better in terms of our ability to do it. The downside is that mass migration that happens from smallholder farms into the cities and the political consequences that deal with it.

Patrick Fine: So, what about adaptive approaches that mix some of the social requirements where society derives benefit from having, say, smallholder farms with technologies that allow those farmers to become more productive? So, you find some sort of balance between a set of social-political needs and then a set of utilitarian needs, the need for food security.

Alex Dehgan: I think that's really smart. I don't think the answer is one or the other, right? I think one of the things we don't want to do is actually double-down on poverty, which sometimes we do with some of our policies that are focused on individuals.

The spread of cell phones, which is itself an exponential, right? It took 20 years for the first 100 million cell phones in Africa. It took three years to get to 300 million. We're almost above a 90 percent penetration rate across most places in Africa. And that is a highly technological tool that people are using, and those cell phones themselves are becoming platforms for unleashing lots of other tools, from mobile money to tools to educate themselves to ways of actually monitoring the weather to actually how they trade grains.

So, I think that adaptive approach is really good, and it gets at this other question, which is technology can frequently be a necessary way to break through a traditional constraint. But, it is not sufficient, and those social and behavioral characteristics and the understanding of the context in which you're in is absolutely crucial. You know, part of the work that we do for Conservation X Labs is not just how do we bring the engineers together, but how do we bring the engineers and the anthropologists together. Because I think it is fundamental to addressing that problem. I think it is a blended approach, and it is empowering individuals.

Patrick Fine: Looking at the people-centered aspect of how technology is applied, I agree is critical to do, and I wonder, as you look at the evolving landscape for technology and how it's transforming work in human development, what

kind of balance do you see between taking a people-centered approach to the application of technology versus a more indiscriminate pushing in of technology? Or maybe it's a more indiscriminate adoption of technology — you gave the example of cell phones. That wasn't really a people-centered approach. That was just a tool that people craved. Who knew that people liked to communicate all the time with so many people? But the reality is, pretty much everywhere in the world, you see people talking on cell phones all the time. So, we love to communicate. But, I am interested in this balance between the benefits of technology and its indiscriminate application or maybe indiscriminate adoption.

Alex Dehgan: I think there are a lot of great things in what you say, and I'll just kind of hone in on two. You know one is just this fundamental question of design. And the first principle is, you start with the problem, not with the technology. When we start with the technology first, I think we get ourselves into trouble, right? And so, if you start with the problem, the first thing you want to ask is are we solving the right problem? If we're solving generally the right problem, are we solving the right constraint that, if solved, would lead to the biggest breakthrough? And what are the potential ramifications and downsides of it? What are the inadvertent effects around it?

And I'll give you an example. Conservation X Labs is focused on addressing underlying drivers of extinction. National parks are amazing. I've built them around the world. But they address the symptoms of extinction rather than the underlying drivers. So, we started thinking about food, right, and this demand for protein. And we started with one place, aquaculture, which is 50 percent of how you get the world's food, and how do you actually deal with feed. Because we do this crazy thing of we catch wild fish to feed the farmed fish which is where 50 percent of your fish comes from, 90 percent of aquacultures in the developing world.

And so, we're thinking, how do we replace that protein source at the same price point and same nutritional value? And so, we looked at insects, the black soldier fly. We looked at how do you actually capture waste flows coming out of aquaculture ponds and turn that into algae and put that back as your protein source? We looked at how you capture carbon out of smokestacks that actually could be turned into protein, believe it or not. And we looked at engineering bacteria and yeast to produce protein. And one of the things we looked at was soy. And the problem with soy is, even though soy could help us easily replace that protein source in aquaculture, it had problems on land. It led to land deforestation. There were problems in terms of its production. It couldn't be necessarily guaranteed. And it was those inadvertent effects or secondary effects that you had to require

to take a systems approach in terms of how you were thinking about those replacements.

So, understanding the problem, understanding the constraints, understanding your user. What is the education level, what is the environment in which they're using it? When they screw it up, it actually means you've screwed it up as the designer and the technologist, right? What is the cost point? What are the distribution systems?

You know, we focus on cook stoves, and the UN Foundation has been amazing with their work on cook stoves. But in fact, the cook stoves may differ depending on why they're using the stoves, what is the fuel source for the stoves, what is it that they're trying to cook? What are the actual dynamics of the pots they're putting on the cook stoves rather than the stoves themselves, and that might vary.

And that gets you into the second question, which is scale. How much of this is a balance between is what you're building something that can go to scale and that reaches? Or is scale something [that is] not really possible because everything has to be bespoke?

Patrick Fine: This is one of the things I struggle with. Within the development community right now, there is a perception that one of the historical failings of development is we have not been able to scale the programs and the products and the services to address poverty. And that notion of scale, I believe, comes out of the software industry, comes out of Silicon Valley, where the products they have to scale to millions of people, it scales rapidly once you've gone through the prototyping. And what I see is that the success in that particular industry has generated a lot of wealth and a lot of influence, and that that wealth and influence now turned to development is saying, hey, you guys, your problem is you're not scaling like we did.

Isn't a lot of stuff that we do in human development, a lot of the social services we provide, they're so contextualized, are they actually scalable in the same way software is? And is there an assumption being made there that is now being, in a sense, visited upon all of us who work in human development, that our problem is we don't scale?

Alex Dehgan: Patrick, this is I think the question, and it's a critical question. And I've made this criticism of conservation. And conservation in some ways has been 20 years behind fields like global health. We're the worst people to bring to dinner. A society of conservation biologists is really a society of professional mourners, right? We document and lament the passing of species. But that's an aside.

But going back to the scale issue: We have had great successes in development that have scaled. We have gotten rid of smallpox, an entire disease off our planet. We have gotten rid of rinderpest, an entire disease of animals that was devastating in terms of domestic animals. We are about to get rid of polio, although as you understand, it is not the presence or absence of a technology, the vaccine. It is literally the social and behavioral cultural factors in Afghanistan and Pakistan that are preventing us from finishing that.

Patrick Fine: Well, and now look at the anti-vaccine movement that's growing up in this country.

Alex Dehgan: And in places like Marin County, San Francisco, which you think is like the center of technology. It's almost a backlash, which I don't fully understand nor fully support. And there is perhaps a new war on science and a war on evidence, and as scientists, we need to understand that actually much, much better within what we're doing. And we're close on things like river blindness as well, right? And cell phones themselves are an example of something that is a technology that is scaled.

Patrick Fine: You could also bring examples from agriculture.

Alex Dehgan: The green revolution scaled in South Asia, but what happened in Africa? And that's a really important question. And how do we do a greener green revolution, improve seeds? The CGIAR System has been important in terms of the sharing of knowledge. I think the internet is incredible in terms of the access to knowledge that we have. And then we have this democratization of science and technology that has allowed people to have technologies that were literally held by defense corporations and others. And I think this is one change that we're seeing in technological development. It used to be all government trickle down, right? The fax machine was used, I think, during World War II. Microwaves came out of the government and its use.

But now we actually see consumer technologies driving that forward as well. And the government looking toward the consumer technologies to actually influence how they're trying to solve problems and how they rethink problems. And there's a great example. My friend started up this company called Planet Labs. It's now called Planet. It used to be called Cosmogia. They've had plenty of names. There were three guys. One of them worked for NASA. And they had this idea. They said, "Look at

Landsat 8. It's an amazing accomplishment of humankind." It cost $950 million to put into space, 10 years of engineering. By the time you choose what you're engineering, you have to certify it for space, which means you can't change it. So, by the time Landsat 8 goes into space, it's 10 years out of date. And it's getting older. And it takes an image of the planet at 30-meter resolution every two weeks everywhere. That's amazing.

These guys at Planet Labs came up with this idea that we're going to use these really cheap satellites, and we're going to use the same technology that came out of your cell phone. And we're going to use consumer products, and we're not even going to shield these satellites against radiation, and we're going to build them for $40,000, $50,000 apiece for a satellite. It's the same kind of satellite that a high school here in Virginia called Thomas Jefferson has put into space. They're about to put in their second – a high school with its own satellites. And they would piggyback on other space launches, and they could put a lot of them in. And in fact, an Indian satellite just put up something like 88 of these nanosatellites into space.

What they've decided is that instead of one satellite, they're going to ring the earth with 149 of them. That's literally the number they have in space today. And the Earth turns in that ring. And by doing that, they can take three-meter resolution, not 30 resolution, of the planet every day, everywhere.

Patrick Fine: Nobody is safe from the prying eyes... *[Laughing]*

Alex Dehgan: No one, no one, no one. But, it's an amazing approach, because it is using and driving and changing the way institutions – they've disrupted NASA in terms of what they're doing by providing a level of resolution in cadence and frequency that will now allow us to understand environmental change in great detail.

Patrick Fine: So, you've given a bunch of examples of technologies and practices that have scaled. So, back to that question I asked about: Is it realistic to think about scaling all the work we do in human development? You're coming out with a pretty strong yes on that.

Alex Dehgan: I'm not 100 percent sure. And even when we scaled some things, it may not have always helped us. And again, going back to as a conservation biologist or extinction biologist or professional depressor, I like to point

out that we have exponentially increased the amount of protected areas around the world since the 1900s. It's an exponential curve. But, we're still in the middle of the sixth extinction.

Patrick Fine: Right.

Alex Dehgan: So even when we've scaled a particular intervention, that intervention hasn't stopped it. The argument you could make, and there's a fallacy in my argument, is, but for those national parks, it could have been far worse.

Patrick Fine: The other thing that has been increasing exponentially during that period is population.

Alex Dehgan: Population, hugely.

Patrick Fine: Which has effects on –

Alex Dehgan: Everything.

Patrick Fine: Right, on the ecosystem...

Alex Dehgan: Absolutely. I feel strongly that you have to take in scale from the beginning, that you have to adapt it through a design process, perhaps locally. And there's a challenge in this. And I don't think I have all the answers, and I don't think everything is scalable. And maybe it's not the individual technology. Maybe it's a system of interventions. Maybe it's how we create those interventions. Maybe it's something like advanced market commitments that allow us to create and incentivize markets for doing it. But, the problem is, without things that are scalable, it's hard to actually find market forces that can help drive things to scale. Digital technologies are the easiest case example to think about scale, because the cost of replication is essentially free. For hardware, it is much harder, but we've been able to do it. But, it takes much more [effort].

My favorite example is having worked on the ground in Iraq and Afghanistan, we had a problem in Iraq where our supply trucks were

getting hit coming in. This is in 2004. We were in the Coalition Provisional Authority. And they said, "We have to ration food. You only get one serving." And I was like, "Well, this is crazy." And so right outside of the green zone was a little Iraqi deli, and I would just go there and buy food, because I wasn't going to be rationed. I'm a big guy. I needed my food servings. And I would buy Pringles. And that's the thing that gets me is, everywhere I've gone in the world, no matter how remote, somehow there's a can of Pringles there.

Patrick Fine: All right, so that's globalization.

Alex Dehgan: That's globalization, but that's also scaling and distribution processes and how you get Coke and Pringles, and you know the other weird thing I found in Afghanistan were those Jelly Bellies. How did you get Jelly Bellies to Afghanistan? What demand, what... you know, because they figured out.

Patrick Fine: What distribution system? I have a similar story. In Senegal in 2000, you could go to very remote corner of Senegal, a two-day journey to get there, and there would be no commercial products for all intents and purposes. Very traditional economy. And yet you could find at a little general store that would only have, you know, rice and sugar and a few soaps. You could find Biscuit. And Biscuit was a cookie that had a chocolate center. And it would be fresh. You could get fresh Biscuit, and it's produced in Bulgaria. So somehow these little chocolate cookies would get from Bulgaria to the most remote corner of Senegal, and you could buy them fresh. So, I used to think, if Biscuit can get here, how come we can't get everything else that people need to this place?

Alex Dehgan: And that's the question. And that's understanding demand, it's understanding how we do it. It's very hard to do. For social enterprises, it's very hard to do for that sector. We have a much harder case to make than Coke does in some ways.

Patrick Fine: One last comment on scaling. One of the books that I grew up with and loved as I was developing my passion for development was *Small Is Beautiful*.

Patrick Fine: And the whole idea that you don't have to do things at a giant scale in order to have a profound impact on communities and on people and on improving standards. So, what I'd like to see is again a balance or a convergence of the idea of taking technologies, so methods and approaches and programs to scale, but to do it in a way so we can also capture those benefits of small is beautiful, which are contextualized and targeted and responsive to people's needs.

Alex Dehgan: One way to think about that is the Peace Corps.

Patrick Fine: Yeah.

Alex Dehgan: And that's a way to kind of capture both of those things and that is one of, I think, the greatest institutions that we as Americans have created.

Patrick Fine: I couldn't agree more with you. I've got one last question. As you look forward, taking into consideration the exponential technologies that we've been talking about and other ones that are on the horizon, how do you think those are going to play into the efforts to achieve the Sustainable Development Goals?

Alex Dehgan: I am profoundly optimistic that we can improve the speed, scale, efficacy and cost of being able to address those goals. I study extinction. I'm in development, and I'm a technologist, so, by definition, I have to be optimistic. Other great thing about having goals — this is an idea that also, at least to some, is attributed to Silicon Valley — is, if you can measure it, you can improve it. And technology helps us do that as well, right? We have a chance to use data to really understand what's going on around the world and really be able to figure out what those constraints are. And then we've got the ability to unlock human potential to be able to take them on.

I think we're at a time and a place, because of this incredible increase in connectivity around the world and the democratization of science and technology, that we can separate work from geography. That where people are and what situations they find themselves in are no longer so greatly limiting on their prospects for success. USAID's job, and the job of international development, really is this recognition that talent is everywhere, but opportunity is not. How do we help facilitate those opportunities to allow people to create this better world? There will

always be downsides, because like I said, technology is a tool, right? Like, I really like driving. Maybe it will really suck to have AI drivers everywhere I go around the world, or maybe there are going to be adverse uses of synthetic biology as a result of advances in the technology. But we also face a world that's free of disease, where people have opportunities that they've never had, that their fathers and mothers never had before.

So, I think it is completely transformative in so many different ways, from our data to our interventions to our ability to deliver those interventions to our ability to empower people to solve their own problems that we can take them on and solve the SDGs.

Patrick Fine: Great. Alex, thanks so much for a really stimulating conversation.

Alex Dehgan: Super fun. Thank you.

Patrick Fine: I also want to thank our listeners. Stay tuned for next month's Deeper Look episode. And you can also find previous episodes on SoundCloud and iTunes.