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## **Kelly on the Future, Productivity, and the Quality of Life** FAQ: [Print Hints](#)

EconTalk Episode with Kevin Kelly  
Hosted by Russ Roberts

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**Kevin Kelly** talks with EconTalk host **Russ Roberts** about measuring productivity in the internet age and recent claims that the U.S. economy has entered a prolonged period of stagnation. Then the conversation turns to the potential of robots to change the quality of our daily lives.

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- ["Better Than Human: Why Robots Will--and Must--Take Our Jobs,"](#) by Kevin Kelly at Wired.com, December 24, 2012.
- ["Is US Economic Growth Over?"](#) by Robert Gordon, Working Paper 18315, NBER, August 2012.
- [Productivity](#), by Alexander J. Field. *Concise Encyclopedia of Economics*.
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## Highlights

Time	Podcast Highlights	HIDE HIGHLIGHTS
0:33	<p>Intro. [Recording date: January 4, 2013.] <b>Russ:</b> Topic for today is a pair of recent essays you've written on productivity, technology in the future, and as always we'll put links up to those essays, other topics. The first essay is called "The Post-Productive Economy." You are reacting to an essay by Robert Gordon that's titled "Is U.S. Economic Growth Over?" His answer is basically yes. He argues that the third industrial revolution hasn't had much effect on productivity, or at least its effects are over. The first revolution was steam and railroads; the second, electricity and indoor plumbing and so on--they had huge effects. The third, computers, the web, cell phones, seems to be over, at least according to Gordon. Its heyday was the 1996-2004 period, and we should essentially settle in for stagnation. It's a very interesting paper. He makes the point that growth is not the norm for humanity. Until about 1750 we were pretty stagnant. That stagnation seems to be the norm. He argues that many technology improvements have a one-time effect. Just to take one example, we can now travel 600 miles per hour in a steel tube called an airplane. Yes, it's faster than a horse. But that number isn't going to be increased much in the future, at least for a while. But you disagree with Gordon. You are more optimistic about the future. Why? <b>Guest:</b> For two reasons. I think Gordon underestimates the degree to which change has already happened. Secondly, by his own calculation, he says that it takes almost 100 years for these revolutions to play out their full effects, and we're no where near 100 years into this third revolution--which, he describes it as being about computers and the internet. And thirdly, I think he is missing in his calculations the true nature of this third revolution which is far more about the communication aspect of it than it is about the computation aspect of it. And we are just at the beginning of that. And then fourthly, I think his metric, or measuring the economic power is incorrect as applied to this new third revolution, because I think one of the things that is changing is actually how we measure our growth. So I think that the nature of the change, the nature of how we dictate our success, is changing. And he misses that, as well. <b>Russ:</b> Let's start with the age effect. He, as you point out, starts his revolution of computers and technology of a recent sort in around 1960. Which I suppose is when the first computers start to come into the world. And your point is that that's the wrong date. Why? <b>Guest:</b> Well, Gordon does not actually give a good reason or criterion for how he is deciding when these three revolutions start or even end. They seem to me to be kind of gut, intuitive, non-quantitatively determined. <b>Russ:</b> Well, they have to be. <b>Guest:</b> And so, he marks the third one as at the beginning of commercial computation. And my argument is that that's probably not a very good place to begin for the third revolution. I agree with him that not much happened with computation alone. I think both the economic and particularly the cultural changes in these electronic gear began with the networking of these devices, from mainframe computers and personal computers and then mobile devices. And that all the kind of transformative effects that we've been seeing and feeling are really all due to what happens when you network them. And in a certain sense it's the <i>Networking Age</i>, rather than the Computer Age, that we should be trying to look at. And if that's so, then the real networking of things did not really begin in earnest until the 1990s. There was some--even internetting. But I know from having resided on the internets very early in the 1980s, it was pretty lonely. There was not much happening. So it was the 1990s really, when the Web began, that this stuff began to be felt. But even if you calculate it from the 1980s, that's still 20 years later than when he was trying to calculate it, from the 1960s and the beginning of commercialization of computers. <b>Russ:</b> It's been a classic measurement question in productivity numbers as to why--I don't have the numbers at my finger tips but this is in the 1980s and 1990s, well before the networking part--why computing hadn't had a large, measurable effect on the productivity numbers. Why we didn't see a spike or at least some kind of large jump. There are a lot of different arguments about that; I'm not on top of that literature. But you are arguing that that maybe isn't so surprising; that the real--and by the way, I should add, part of the reason I think that was raised is that a lot of corporations were spending a lot of money adding computing to their capital. And so people were saying: If they are spending all this money there must be some bang for the</p>	

buck; Where is it? And of course, as you point out, some of that took a while. It took awhile to figure out how to use computers effectively in manufacturing and personnel management and other areas. **Guest:** Exactly. In fact, it was Robert Solow who made the quip that we see the effects of computers everywhere but-- **Russ:** in the data. And there was a fellow actually, a guy named Paul Strassman, who wrote a book called squandering computers. I don't know if that was the name of the book--he was from Xerox and he was preaching, and I would say this was late 1980s, the fact that there was no economic case for all these companies spending huge amounts of money for computers, which were very expensive at the time. And it was hard to argue with his numbers. Because in fact there were large outlays for computers and it didn't seem to really benefit the total economic case. And in fact I even remember doing an interview with Peter Drucker, who made the case in the early 1990s that from his perspective there had been no money made in the computer industry. He meant in terms of as being a net gain to the economy. And he made the point, too, that it would take a long time until there was a net gain in terms of the total amount of money spent and the total amount of difference made. So, I think that the facts are pretty clear that there wasn't much to the gain in those years. And I see it more as kind of laying a foundation of change. And change not just in terms of having the hardware and the iron turned on, but a change in the way a company is structured. Just sort of preparing the way in which software would play a new role and communication would play a new role in the structure of an organization. So it was a type of investment if you want to think about it-- **Russ:** Oh, for sure. **Guest:** in organizational change necessary; and it took a generation of economic or corporate lifespan to prepare for that.

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9:50 **Russ:** Just to take a personal example on this point on productivity--I've told this story before; forgive me, listeners, for retelling it. But I had my first personal computer in 1984, which was a Mac. And at the time, if my memory is right, it could only create a 12-page document. If you wanted to make a 20-page document, you had to combine two 10-page documents. Of course, it crashed; a little bomb would show up on the screen. You had to learn how to use it. And my Dad was a very happy user of a yellow pad and a pencil. And I'm sure he thought I was wasting my time learning to use this technology that really, you had to kind of talk yourself into that it was a time-saver. You had to say: well, if I want to do a second draft it's easier. But it had all these huge costs. And my Dad--thank God he's still alive at 83--is still using a yellow pad. He does have someone enter his essays and articles and letters into a computer. So he never got used to using a keyboard, even. And I know many people over the age of 75 who were in that world. They still use a pencil; they still use a yellow pad. Nothing wrong with it. It's a very, very effective technology. And you could still argue that there are many time-wasting aspects to computers. But the productivity increases just for research alone have been so extraordinary. Obviously you can save time from traveling to the library, traveling out of your country--data, articles, resources, references. So, that was a good investment by me, I think. **Guest:** Yeah. And there's lots of these examples we can think of in real life and past life where you are required to invest into learning and during the learning curve you are not as efficient or graceful or accomplished. But at the other end of it--it's like learning how to type or something. When you begin to learn to type you are going to be much slower than writing it out. But you can type faster than you can write, once you get good at it. **Russ:** I do have to concede to my Dad that the real reason I bought that computer was because I thought it was cool. It really wasn't that I thought that in 2012 I'd be on the Internet. **Guest:** Right. But I'd like to come back to that, because I think that's actually a very, very important point. And we can use different words for 'cool.' But I think that we often--a lot of our economy now is about cool things. Not just things that make you able to do things faster.

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12:30 **Russ:** Well, let's turn to that, because that was one of your other criticisms of Gordon. I've forgotten 2 and 3, but 1 and 4, the last one being he doesn't measure what necessarily we should be measuring. And one of those things--'cool' is I think the wrong word--'exhilarating', 'inspiring.' Talk about why you think productivity per se is the wrong measure to evaluate this revolution. **Guest:** Because--when I look at the long course of human endeavor and civilization, Gordon is correct that for a very long period of time, the growth in, say, living standards or progress, however we want to describe that, was actually very minimal for very long periods of time. **Russ:** Life was nasty, brutish, and short. **Guest:** Yeah. And for most of human history, for the bulk of it, people were starving. Or always hungry. This is the recurring theme throughout--Malthus was correct. The population would always kind of expand just to the point where people were on the edge, constantly. And it wasn't until our greatest invention, the invention of science, the Enlightenment, and a whole network of other ideas, where we were able to actually solve that problem, of food, and in its surplus start to create new things. And we--beginning in the 1700s, 1600s, wherever you start to map that--there was a huge uptick in many things, including human population, which suddenly could really start to expand. And there was expansion of other things, and this kind of sense of accelerating change--in lifespan, education, literacy, economic wealth, all these kinds of things. And if we look at that on a centuries' scale, it's kind of peculiar, because there are things that are kind of coming out of nowhere. There is this generative, a generation of things that did not exist before. There's huge amounts of money that now flow around. Where did that money come from? Basically it was created out of nothing. And so there is new things being created. And I think the purpose, in some sense, of what technology is for is to create new things. And by definition when we create something new, we don't have very good ways to measure those things--because they are new. And in a certain sense, if we want to just kind measure the *newness* of the economy, that's also hard. Because if they are truly new, they may be served completely beyond anything of our experience, and we don't have a good way to measure newness.

So, what I'm suggesting is that being able to make things that we already know that we want with less time and less resources is part of the story. But it's only *part* of the story. It's not the whole story. It's the basis of how we got started to begin with: we were able to grow more food with less time and less resources to make sure everybody had it. And that was the beginning of our prosperity. And it's still the foundation of it. And new technology allows us to generate the things that we want using less time and less resources, and therefore less money. Leaving the surplus to do other things. What are those other things we want to do? In brief, it's to invent new things. **Russ:** Yeah. **Guest:** So, inventing new things is really the real engine. And as productivity does continue, it means that the making of new things becomes a larger and larger part of what our civilization and economy is about. And yet, productivity, Gross Domestic Product (GDP), is only measuring the old part. Which is how to do things that we know how to do more efficiently. Well, as you say, we struggle to measure new things. The classic issue in GDP accounting is boring, equally important price indices, when we are trying to measure our standard of living and prices aren't constant, is quality change. So, when quality improves we have trouble making comparable adjustments. For example, a TV today until recently is much cheaper than a TV of 60 years ago, where 'cheap' means: how long does the average person need to work--how many hours does the average person need to work--to earn one? But now a lot of TVs today, some of them are *more* expensive. And that's because what they do is so extraordinarily different than what a 1960s black and white TV did. It's not just, oh, it has more channels, it last longer, it takes fewer people to make it. It accesses things in your house and in the world that you couldn't have imagined--literally couldn't have imagined--in the 1960s. **Guest:** Another example would be a phone. What's a phone now? It's like not really a phone--it's really different. Is a phone--are we being more productive in our making of a phone? Well, it's a ridiculous question, actually.

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18:45

**Russ:** The other way to think about it, that your example makes me think about, is entertainment. I was just re-watching *Shakespeare in Love* the other night, which is one of my favorite movies. And you think about England in Shakespeare's time--what proportion of the population was involved in something called 'giving other people a pleasant evening of just entertainment'? And the answer, I think, would be a few hundred. Those would be the actors, the people who worked on the stage. There wasn't a lot of lighting, but whatever they did--curtain work and constructing and other things. There were a handful of people who could be playwrights in that time. And you compare it to how many people today. I mean, just look at the credits of a modern movie, and look at how many people worked, obscure to us and certainly people before modern times, but unless you are an expert or inside the industry you have no idea what these jobs are. The number of people who would be described in a perimeter of times as 'unproductive.' You call it, I think in your paper, as "wasteful." But you put it in quotes. It's not related to food, housing, and clothing. It's just nice. It's just cool, fun, exhilarating. It's just beautiful. The proportion of people doing that in modern times is just enormous, vast. And I don't think we are capturing that. Even though they are making a living. They are in GDP. As you point out: It's hard to make that comparison when these are new things. **Guest:** Right, exactly. I'm a little hesitant to just talk about fun and beauty, but a term that's maybe more in line with economics would be to use the words 'to explore.' And 'to experiment.' You can kind of recast art if you wanted to in terms of exploration and experiment, because those words also apply to both research and science. So, there's a real typical dilemma in medicine which is that if you were rational you would only ever take the most perfected medicine that has been proven. But if everybody only ever accepted the proven methods, there would be no advance. So at some point you actually have to give an experimental drug or procedure to somebody, where there is no guarantee that this is going to work; there's a very high risk; it's not proven. And so that is inefficient in a certain sense. You are for sure going to lower your statistics on that one. **Russ:** Yep. Probably. **Guest:** But we pay that tax. We pay that penalty of decreasing the perfection, decreasing the optimization in order to have long term growth. And what I'm suggesting is that as we speed up, as we accelerate, that portion that we spend on the non-optimization is growing. And that in fact it is becoming more important to us. Because, optimization is really for machines. It really is something that mechanical things--it's really not something that humans really want. We really don't tend towards optimization. And I'm suggesting that whenever we have an optimization problem or something, we really send it to the machines and mechanical systems and leave us with this playfulness, experimental, exploration, art, beauty, all these other things that are non-optimizing. **Russ:** Well, let me ask you a difficult question, but I think it's the right one. You may not be able to answer it but I'd like to hear what you think of it. Tyler Cowen, somewhat akin to Robert Gordon, has argued that we're in the Great Stagnation, as he calls it; we've picked all the low-hanging fruit. And, similar to Gordon, we've dissipated and exhausted all the potential gains from this technology and now all we are doing is improving Flickr. Or allowing Flickr to give you a black background instead of just a white background. Those are the kind of technological improvements that we're up to now. The smart phone is done. The internet is there. And all these gains have happened. So, my question is--again, somewhat unanswerable: What could we possibly imagine is yet to come in this revolution that will take it up another notch or two or three. Let's forget whether it can be measured or not. One of the things that's extraordinary to me about the world we live in is that it's certainly true that 100 years ago people couldn't imagine the things we're doing now. And when you are talking about health--I imagine describing computer-driven laser surgery to someone 40, 50 years ago. It's impossible. But what might happen in the next 50 years that we would think would be unimaginable? And that's why it's an unanswerable question. Where are we headed that might give us

some of the amazing changes that we've seen in the past but yet are still to come? **Guest:** Let me address the stagnation question, which actually I have more sympathy for it in a certain sense than you might suspect. But maybe in a slightly different angle. I think it's entirely--let me put it this way. I think if you calculate the number of hours, person-hours, hours worked, the number necessary to discover something new--that's increasing. Like, if you go back in history it would be like Michael Faraday and Thomas Edison. These guys were going into the basement and discovering things every night. A lot of the kind of inventions and stuff done a couple hundred years ago were low-hanging fruits. Even things like discovering electrons and photo-voltaics, discovery was a low number of hours of investigation. If you look at a modern paper, the Higgs boson, something like that, the number of hours that has taken people to divine that mystery of the universe, it's enormous. And I think, as we go forward, that we have in a certain sense reaped a lot of low-hanging fruit in terms of discovery, and it may be that the number of hours it will take to, say, understand gravity, discover the graviton or whatever, or anti-gravity, is going to be enormous. So there may be a sense in which what we are seeing is that the low hanging discoveries have been discovered and that it takes, like the credits on a movie film, it just takes an enormous number of hours and energy to discover the next thing. **Russ:** An army. **Guest:** Right. And I think it's no coincidence if you look at the average number of authors in a science paper, it kind of continues to go up and up and up. And that's in part also because we now have the tools, that allow that kind of cooperation, so they are working hand in hand. So, I'm sympathetic to the idea that there are low-hanging fruits. However, I haven't read Tyler's books, so I don't know exactly what his arguments are. But responding again to Gordon's paper and his arguments about the stagnation, and again come back to two reasons. Yes, we may have a temporary moment of stagnation as the next thing kicks into gear, and what is that next thing? What could possibly be greater than all the things we have already invented? I think, for myself, I think the answer is that we are making something at a global level that has not existed on this planet before, that is categorically different, that's immense in power. And that is this, if you think of all the things in the world that are on the network, all the devices that are connected to each other, all the people in the world that are now part of a kind of a global culture and a global economy, and if we continue going in that direction we are making a planetary something that will have effects at the planetary scale. And global warming is sort of one bit of evidence--that already our technology *is* planetary. But it's only one of many indices that will reveal themselves, that we are making this sort of planetary thing. With all the world economies interlocking, with information and processing all being kind of distributed in this cloud where we have kind of global citizens watching the same movies, listening to the same music, studying the same things in school, using the same devices. I think this is where we need to look for this amazing thing that's going to start to emerge.

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29:36

**Russ:** Well, I'm not as--I don't know about that. That's a hard sell. And of course it's inherently speculative. I guess what I would think about is, we think of all the things that we enjoy day to day. We just did a recent episode with Esther Dyson on this issue of attention, and what we pay attention to. So many things that we pay attention to are not monetary. Again, a measure I think of our incredible wealth. But as that happens and as the tools for sharing change, I think the potential to create extraordinary things, it changes in a non-discrete way, in a quantum way. To take an example from my own life, I made this rap video about Keynes and Hayek with film-maker John Papola. And the two that have been made have been seen over 6 million times on Youtube. And I think about what it would have been to do that 20 years ago. Twenty years ago, 25 years ago, 15 years ago, we'd have made a video; we'd have put it on a DVD, and then we'd have tried to sell it in the back of magazines. Distribute it to schools. It just would have been--the scale of things has changed so dramatically and the ability of talented people, of which there are an almost infinite number, to bring their creativity to bear using technology to make videos, to make music--the things that move our souls--there's never been a more creative time in human history. **Guest:** What's interesting is that doesn't even get counted in GDP, because you're probably giving it away for free. **Russ:** Oh, absolutely. **Guest:** So that whole thing, the 6 million views, your creation of it, is not even registered. **Russ:** And just to give it a little bit of pretension--I mean, I don't want to go too far--those two videos I hope don't just add up to 17 and a half minutes of entertainment. They encourage people to learn about Keynes and Hayek and change what happened in some classrooms because kids watched it, talked to their teachers and fellow students about it. I think those changes, besides--again, I don't want to downplay delight. I love delight. I think delight's glorious and can be transcendent when it's the right kind. But I think the ability to get people to think and share ideas with others is just glorious. I'm not saying we're going to cure cancer because of that, although I think we will. But there's just a lot more stuff going on there that we can't imagine. **Guest:** Right. And that was another point of my piece, in my argument against Gordon. I think often times those ideas that are generated through the use of technology will seep into the society at large and eventually will have an impact on the productivity of things, in a very indirect way, as they become established. Okay, you did a rap video about Keynes and Hayek. Well, that, sooner or later will flow down, be seen by millions and millions and have some impact on people's approach to setting up policy in terms of funding. And it will eventually have some impact on productivity. **Russ:** Well, that's a lovely thought. But I don't know if that's true, even a small effect. I think your other point is the more important point, which is: I don't care if it has an impact on productivity. Right? Measured productivity, anyway. I think as economists we are not just accountants. Part of our job is accounting. But a lot of what you are talking about is intangible, non-measurable, and as you say, I think

the key point is not just you get more from less. You get different. And different is the great thing we get because we can afford to get it. We don't just want better food. We like it; we are going to get that; it's already close to free. Poverty in the United States and in much of the world--unfortunately not all of it--the cost of food isn't the problem. The problem is other things. And so, those revolutions, they *have* played out. It's *different*, not just better or cheaper or more from less. **Guest:** Right. Exactly. And so measuring difference is extremely difficult because it's new. I'm not an economist but what I would urge a young economist who is kind of interested in revolutionizing or understanding economics was to focus on how do you measure things that haven't been measured before. How do you measure possibilities. How do you incorporate in that kind of infinite game of constantly heading into new territories as the measure of what you are aiming for. As the goal. That would be fabulous. **Russ:** Yeah. I encourage that as well. And I encourage equally, young economists out there to remember that not everything valuable can be quantified, and if you can't ever measure it that doesn't mean it's not important.

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35:29

**Russ:** I want to shift gears here. I want to move to your second essay, which is related to the first. You wrote an essay for *Wired* called "Better than Human." And you note that that's not your title. One of the strange things about writing in print or for the web is often you don't get to choose your own title. Everything else you get to write, but they write the title. For some reason. Evidently, you wouldn't have chosen the phrase "Better than Human" to describe the future world of robots that are coming. But you start off in that essay by making an analogy to farming, an analogy I've also used. I think it's a phenomenal analogy. You start off by saying: Imagine a world where 70% of us lose our jobs, and why is that relevant for farming? What's the connection? **Guest:** In the first agricultural revolution in America, at the peak, 70% of Americans were living on farms. And now there's less than 1%. So, all those farmers, over a long period of time, have lost their jobs. To talk to those farmers back then and try to console them, they would have found it very hard to believe that there was anything for them to do. **Russ:** They also would have presumed there would be mass starvation. If only 1%-- **Guest:** Exactly. Right. How does this work? You are telling me a fantasy. They would be rolling their eyes and saying you are making this up. And you'd say: No, no, no; there's less than a percent of you on the farms and we have more than enough food--we are too fat. And we are doing all these other things. So there would be great concern among themselves as to the improbability of having anything to do, of having work. And I'm saying: Well, 70% of everything that we're doing now, all the jobs, people who are accountants and mortgage brokers and pharmacists and all these folks--those jobs are going to go away in the next whatever-it-is, the next 50, 90 years. **Russ:** And they are not just going to India and China. They are going away, period. **Guest:** Exactly. Right. In fact, there was a whole section of stuff I wrote that did not get in, but one of the points was outsourcing was just sort of the first step to robotization. So anything you could imagine being outsourced would eventually make it to the cheapest coolie labor, basically, that we could come up with. So, these jobs would be taken over by machines. Which, by the way, is exactly what happened to the farmers. It's not that farming went to India and China. It's that the farming went to robots. We mechanized it. We invented all these machines that are almost robotic and becoming more so every year, including ones that now self-drive. They go up and down the fields and there's nobody driving them. I mean, they are robots, computers driving them. In fact some of the last remaining hand parts of those picking strawberries are also, there are now robots that are very close to being commercially placed, the pickers. So that metaphor, the parallel of the unthinkable happening to farmers is going to happen to us. And it's just as unthinkable to people today as it would have been to the farmers of a century and a half ago. **Russ:** And so an example in my world would be teaching. It's not obvious that 50 years or 10 years that there should be--there might be for political reasons--but there should be teachers. Maybe. I think there probably will be teachers. **Guest:** There will be teachers, but fewer in number. And again, farmers have not disappeared. The numbers have. There are people who call themselves farmers. There will be people who call themselves teachers. But there may not be as many of them. **Russ:** And they will be doing very different things than a teacher of today does. Because of the opportunity to learn online and share knowledge from the best teachers. Going back to my earlier point, it's possible to imagine that a handful of the best teachers will do all the teaching. Just like, as Nassim Taleb pointed out in one of his books, a handful of singers sell all the albums. In the old days you could make a living as a singer because that's how you got music. You had to go down to your local hall to hear the best music in your neighborhood. That's not true any more. I hope that will happen in teaching. I hope that the world's best teachers will teach millions rather than 30. **Guest:** But let me just stop there because I think the essence is a little bit incorrect. Yes, there is this head of the curve where a few people are selling lots of the hits. However, you go on Youtube, how many people are actually singing and have an audience? More than ever. **Russ:** True. **Guest:** And I think this is what will happen with teaching, is that yes, the kind of professional teachers become few and they do a lot of the head; but you have the long tail teaching in which we see this happening, again, in people doing Youtube tutorials. I am just astounded about what you can learn or see on how to learn something, how easy it is, and how quickly the next generation is going to the web and places like Youtube to be taught. Whether it's something academic, like how to square a circle or something, or how to finger a piano piece. That's where they are going to learn. And so in a sense, teacher duties are distributed widely to the long tail. **Russ:** Yeah, great point. Totally agree. I'm talking about the urge to hear the *greatest* voice. It can now be delivered via Youtube, for example.

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42:05

**Russ:** But anyway, let's talk more about robots. There were a lot of changes in robotics recently that give us a little taste of how that world could change in our lifetime. What's happening? **Guest:** The main thing that's happening is that a number of technological advances in perception, cameras, Artificial Intelligence (AI), and stepper motors and things like that, have converged to make a personal robot possible. And a personal robot is a robot basically that anybody can program and instruct. The situation in the world right now is that most of the robots are industrial robots. They are extremely expensive, and they require basically a Ph.D. to train and program. And so this is very akin to the mainframe computer of old, which was big, bulky, and you had to wait in line to give it your instructions in batch mode, and you couldn't change it while it was running. **Russ:** And you had to be a specialist-- **Guest:** You had to be a specialist to talk to it. And if you were someone who used it, this person was kind of a priest in between you and it. The personal robot is the equivalent of the personal computer, the PC, which is that it is affordable generally to anybody. You can do it. And also, like the PC, it will be considered a toy at first. It seems toy-like in terms of its capabilities. It's not very precise. It's very limited. And there is a sense to dismiss it, like the early PCs, as: What are you going to do with this? **Russ:** Yeah, like my 12-page Mac. **Guest:** Exactly, right. And so, but, what happens is, like the PCs, yeah, they were kind of toy-like; but they were getting twice as good every year and half as cheap. And so in a decade you have this amazing thing. And this is what's going to happen with the personal robot. At first, it will be the equivalent of putting your recipes on it, like you did the PC. There will be people who are mostly in small businesses who want to pack up boxes or fairly limited kinds of things like assembling parts. Doing very, very specified repetitious things. But they'll be able to do them at a price that's cheaper than hiring a person. And not just a person in the United States but even an outsourced person. And so, we have Foxconn which now makes all the Apple products. One of the largest employers in China, with a million plus employees. Who are becoming a little unhappy and restless with their jobs; and Foxconn says: We're going to buy 1 million workbots in the next couple of years. And basically to do all the jobs that even the Chinese migrant workers don't want to do. The reason why I mention that is that basically this means that these robots will be cheaper than even Chinese and Asian laborers. **Russ:** Well, just like they are now. There's a lot of robotic assembly, mechanized assembly, in China relative to 25 years ago. I remember talking to someone who outsourced sweaters from China, and 25 years ago a factory in China was a bunch of women with knitting needles. That was a sweater factory. That's not what Chinese sweater factories look like these days. **Guest:** No. Right now, all the manufacturing, it's mostly assembling that's being done. And one of the reasons that's been slow to roboticize is that it changes. It's flexibility. And this is what these personal robots are going to shine in--the way you program them is you either stand in front of them and show them what you want done, or you move their arms, showing them what you want done. It's kind of a show-and-tell rather than programming language. And that makes it very fast to change what they are doing, to shift them around, to give them a small job where they work for a few hours and then you tell them something different. And that's what humans-- **Russ:** we're good at that. **Guest:** We're really great at that. **Russ:** Wash the dishes. Rake the leaves. **Guest:** Yeah, exactly. It'll be a long time before you have household personal robots. But maybe not as long as we're thinking. Just in the same sense as how long was it since the first Altair or Commodore to the iPhone. That was maybe a couple of decades. And that would not have even been perceived as possible back in the 1970s and 1980s. So, that, though, is--we think of physical things but what I want to emphasize in this revolution is--there are robots and there are bots, and bots are kind of software things that are AI-ish-- **Russ:** Artificial Intelligence-- **Guest:** that are going to be doing many of the jobs that people sitting in front of computers are doing today. And so it's not just the factory workers or even the farm workers that are going to have their current jobs replaced by this, but even people who are sitting in front of computers. And things like Siri, we get the voice activation thing inside of an iPhone, or Google spoken software, these are kind of hints at how fast these are going to accelerate as these things get half as good and twice as cheap every year.

48:29

**Russ:** So, I have to fight off the urge to think about *Sleeper*, Woody Allen's movie. Put that movie to the side, mentally. And I want to ask a scary question which came up in a podcast I did with Robin Hanson, which is a reference to the singularity, the possibility that artificial intelligence will advance so far that essentially there will be nothing that we can do better than robots. Whatever that means--robots, it will be more than things we just think of as robots. That will be, as you say, there will be graphic design done by robots; it won't just be robots sitting at a computer manipulating the mouse. It will be something unimaginable. And that therefore there's going to be nothing left for us to do well. Except for the people who know how to design and improve robots, they'll live well; but the rest of us will struggle and we'll be a dime a dozen, or a dime a million. And as a result--his vision of the future is fairly bleak. Even worse than Robert Gordon's, I would say. And he's not alone. There are a number of people who are worried about machines, artificial intelligence, technology "taking over the world." And my view--and I want to get yours--but I want to get mine down because when I talked to Robin Hanson he pushed the view that we are just chemicals and it's just a matter of time before all the chemicals get figured out. And I just, having done some reading since then I don't think that's a universally held opinion. But I guess, to give his view its due, a robot, artificial intelligence, will eventually create a cleverer and more beautiful version of the Keynes-Hayek rap videos that I did with John Papola. And all these creative things that we think, that's going to be our specialty--that's going to be gone. So, are you worried about that? **Guest:** No, I'm not. My reasons may be a little complicated but let me see if I can state it briefly. **Russ:** Take your time. **Guest:** The basis

of my non-worry comes from the fact that I think the idea of universal computation is a myth. And by universal computation is the belief that starting with the mathematical idea called Turing-Church hypothesis, which says any computation is equivalent to any other computation. The full version of that is: Any computation is equivalent to any other computation given infinite time and space. **Russ:** Slightly different. **Guest:** And the problem is in the real world all computation is finite. Bound by time and space. Which kind of comes to the point that the matrix, the substrate, the foundation that you do your computation on matters. And that means that the kind of intelligence that you'll get when it's based on silicon, even if you are trying to do an emulation of the kind of computation that happens on wetware--

**Russ:** That's you and me. **Guest:** That's you and me. Because of the fact that you want this in real time, is not going to be the same. And so what that means is that intelligence is not a single dimension. It's multi-dimension. There are many, many different ways in which you can be smart. And not just you. Your calculator is smarter than you right now in arithmetic. It doesn't freak you out just because it's a different kind of intelligence. And so what we are going to do is, there is really almost no reason to make human-like intelligence because we can do it so easily in 9 months. Untrained workforce. **Russ:** Yeah. **Guest:** What we want--this comes back to differences. What we want is to think different. We want different kinds of thinking. And the whole point of the AIs that we are going to be making is they are going to be thinking differently. And that's tremendously valuable, because lots of things also puzzles and mysteries we are going to figure out may not be solved with only human intelligence. We may need other kinds of thinking to get there. And so what will happen is we may fill the world with a million different species of intelligence, some of them vastly superior to us in that dimension. But humans will have an unimitable type of intelligence. And we, being humans, will really like that kind of stuff. So we will continue to amuse ourselves with this type of intelligence. And so I'm not worried about our place when there's a million other kinds of intelligences. Because I think that we will still find our own kind valuable to ourselves. And reward it. And we'll find the other ways of thinking to be extremely valuable and we'll continue to make and invent new kinds of intelligences, including those that are super-intelligent in that direction. **Russ:** I suppose the pessimistic view is that--well it starts with chess. First, early computers couldn't beat a person, and now it's very hard. They are really good at it. They will soon, maybe they already have--not my specialty--but the best computer will easily beat the best human being in chess. And you could say: Well, chess is not important. It's not; I don't think it's is. It's nice but it's not important. But soon then they'll be better at poetry and symphonies and music and movies. And there'll be nothing left for us. So, you don't think that's going to happen. **Guest:** Well, no, I think it *is* happening. I think we are constantly redefining what humans are good at. Well, humans play chess. Well now we saw humans don't play chess. They play checkers. They play Jeopardy. Oh, well, that's not really bad. So I think we are really onto a whole century of identity crisis at the species level, of well: What *are* we good at? But and so I think this is going to be a long-term, painful identity crisis, where we kind of keep saying: Well, what *are* we really good at? I'm not saying it's necessarily going to be happy the whole way, because I think this is painful. I'm just saying that the robots are not going to take over and kill us all and turn us into slaves. Or batteries, like in *The Matrix*. I think that what we are going to be doing is like anybody else. When you are growing up you spend an awful lot of your 20s and your teenage years trying to figure out: What am I good at? What is truly mine and mine distinctively? And it usually takes your whole life to finally come to that. It's not an easy journey. But I think you'll get there. And I think the same thing is happening to us as a species. We are saying: Oh my gosh, we thought that we were a chess playing, Jeopardy playing, checkers playing species. But it turns out that actually that's really not our movie. We're something else and it's going to take us maybe a century to maybe come up to a better idea of what humans are good for. **Russ:** Well, there's one issue about what our standard of living is going to be in this world. The other issue is what is going to give our lives meaning. I think a lot of us find our meaning in our work. We find it in our family, in our religion, in our play. We find it in lots of ways. I think there are different dystopias that come out of this vision-- utopias. But the dystopia is: We'll be so rich that we'll just sit around and surf the web all day. And that may be a very depressing existence. It may be a very fat existence, in terms of calories available and how much we have to work. But I think the other challenge will be where we get our meaning from. **Guest:** Well, actually I propose a place for that meaning in my book, *What Technology Wants*, and I am suggesting that the meaning will come from understanding that what technology is is an extension of the same self-organizing life force that runs through life and actually began at the Big Bang, at the beginning of the universe. And what it's moving us towards in all things is towards increasing possibilities and options. And when we make stuff, invent new things, with technology, we are participating in that long arc that runs through the universe and out and beyond us of increasing options, freedoms, choices, and possibilities. And that that actually can give us some meaning in our lives.

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COMMENTS (31 to date)

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