SINGULARITY: UBIQUITY INTERVIEWS RAY KURZWEIL

[Ray Kurzweil is one of the world's leading inventors, thinkers and futurists. His latest book is the just-published "The Singularity Is Near."]

UBIQUITY: How is the new book doing?

KURZWEIL: Very well -- it's in its fourth printing, and has been number one both in science and in philosophy on Amazon.

UBIQUITY: It's an amazing, magisterial piece of work.

KURZWEIL: Thanks, I appreciate that.

UBIQUITY: Why don't you talk a little bit about the notion of "singularity"? Set the premise for us.

KURZWEIL: Sure. It's actually a complicated premise, but there are several key ideas. First of all, there's the idea that technology in general is accelerating rapidly, and information technology in particular is doubling its power, as measured in price performance and bandwidth capacity, every year. We will see the power of information technology multiplied by a factor of a billion in 25 years. If you imagine increasing the power of computers for the same price, computation, communication, as well as our knowledge of biology, and knowledge of intelligence processes in the brain, by a factor of a billion in 25 years, it's quite a formidable result.

The second observation is that information technology is not just computerized devices like MP3 and cell phones, but is something that is deeply influencing every aspect of our lives, including our biology, our knowledge of intelligence, worldwide communications, and so on. People say, well, exponential progressions can't go on forever: like rabbits in Australia they eat up the foliage and then the exponential growth stops. But what we see actually in these information technologies is that the exponential growth associated with a specific paradigm (like, for example, shrinking transistors on an integrated circuit, which underlies Moore's Law) may come to an end, but that doesn't stop the ongoing exponential progression of information technology -- it just yields to another paradigm.

UBIQUITY: Example?

KURZWEIL: A good example is the fact that the integrated circuit was not the first, but the fifth, paradigm to bring exponential growth to computers. They were shrinking vacuum tubes in the 1950s, and that came to an end.

They couldn't shrink the vacuum tube and keep the vacuum, but it just led to another paradigm which were transistors. In the book I ask, what are the ultimate limits of matter and energy to support computation and communication? Yes, there are limits, but they're not very limiting. One cubic inch of nanotube circuitry would be 100 million times more powerful than the human brain. So there's going to be plenty of capacity with three-dimensional molecular computing to keep these trends going for a long time.

UBIQUITY: How will this all play out?

KURZWEIL: There are two key aspects to the concept of singularity -- the hardware and software sides of emulating human intelligence. We'll have sufficient hardware to recreate human intelligence pretty soon. We'll have it in a supercomputer by 2010. A thousand dollars of computation will equal the 10,000 trillion calculations per second that I estimate is necessary to emulate the human brain by 2020. The software side will take a little longer. In order to achieve the algorithms of human intelligence, we need to actually reverse-engineer the human brain, understand its principles of operation. And there again, not surprisingly, we see exponential growth where we are doubling the spatial resolution of brain scanning every year, and doubling the information that we're gathering about the brain every year. We're showing that we can turn this data into working models and simulations. There's also two dozen regions of the brain, that we have modeled and simulated, including the cerebellum -- which is where we do our skill formation and which compromises more than half the neurons in the brain. There's an effective simulation of that.

UBIQUITY: And this leads to what?

KURZWEIL: I make the case that this exponential progression will lead us to an understanding of human intelligence. And by understanding I mean we will have detailed mathematical models and computer simulations of all of the regions of the brain by the mid 2020s. So by the end of the 2020s we'll be able to fully recreate human intelligence. You may wonder: "OK, what's the big deal with that? We already have human intelligence; in fact, we've got six billion human brains running around, so why do we need more?" One of the answers to that question is that it will be a very powerful combination to combine the subtle and supple powers of human pattern recognition with ways in which machines are already superior. Machines can think more quickly than we can. They're much better at logical thinking and much better at remembering things: a $1000 notebook computer can remember billions of things accurately whereas we're hard-pressed to remember a handful of phone numbers. And most importantly, machines can share their knowledge,

their skills, and their insights at electronic speed, which is a million times faster than human language.

My second point is that nonbiological intelligence, once it achieves human levels, will double in power every year, whereas human intelligence -- biological intelligence -- is fixed. We have 10 to the 26th power calculations per second in the human species today, and that's not going to change, but ultimately the nonbiological side of our civilization's intelligence will become by the 2030s thousands of times more powerful than human intelligence and by the 2040s billions of times more powerful. And that will be a really profound transformation.

UBIQUITY: Why do you call this profound transformation the "singularity"?

KURZWEIL: The "singularity" is a metaphor borrowed from physics, really referring to the event horizon. We can't easily see beyond the event horizon around the black hole in physics. And here with regard to this historical singularity, we can't easily see beyond that event horizon, because it's so profoundly transformative. We will literally multiple the intelligence of our civilization by merging with, and supplementing our biological intelligence, with this profoundly more capable nonbiological intelligence by a factor of billions, ultimately trillions. And that will dramatically change the nature of human civilization. That in a nutshell is what the singularity is all about.

UBIQUITY: Somewhere in the book you remark that people have a very hard time understanding exponential growth, isn't that right?

KURZWEIL: Yes, that's a very good point, and a very important one: it really underlies the difference between the seemingly radical projections I'm making and people's linear perspectives of what will happen. People intuitively think that the current pace of change will continue at the current pace, and when I say "people" I'm definitely including sophisticated people, scientists. I had a debate recently with someone who is reverse-engineering the human brain who was engaging in a linear extrapolation. He said, "Well it's going to take me 18 months to finish modeling this one ion channel. And there's five other ion channels, and that's five times 18 months. And then there's other details, and this other dendrite has six more ion channels." And he's adding it all up in his mind, and saying "Well, it be 100 years before we finish this project, assuming the project is going to go for the next 100 years at the same pace, with the same tools, with the same supercomputers to do the simulations." And I'd add: without factoring in the radically changing landscape. The fact is that the pace of progress is dramatically increasing.

UBIQUITY: What could you cite as an example of this?

KURZWEIL: It took us 15 years to sequence HIV. We sequenced SARS in 31 *days*. So someone doing the mental experiment in 1990, about how long it would take to do, for example, the genome project also came up with centuries to do the project. But we doubled the amount of genetic data we have been sequencing every year. And that has continued. We are doubling the spatial resolution of brain scanning and so on. The future is exponential, not linear, and yet virtually all government models used to track future trends are linear. They actually work quite well for one year, two years, maybe three, since linear projection is a very good approximation of an exponential one for a short period of time -- but it's a terrible one for a long period of time. They radically diverge, because exponential growth ultimately becomes explosive. And that is the nature of technological evolution.

A related issue is can we really predict the future? The common wisdom is that you cannot. But I maintain that you can reliably predict these features of information technology. If you ask me how much will a MIP of computing cost in 2010, or how much will it cost to sequence a base pair of DNA in 2010, or what will the special resolution be of brain scanning in 2014, I can give you a figure, and it's likely to be very accurate. And I say this now, not just looking backwards at this data, but I've been making forward-looking projections like this for 25 years that have proven to be quite accurate, even though they were largely controversial when I made them.

But someone might say: How could that be? How are we able to make reliable predictions about the overall future of these technologies when each individual project is very unpredictable? But we see the same thing in other areas of science. Take thermodynamics. It's impossible to predict the path of a single molecule in the air, because it follows a random unpredictable path, and that's true of all of the particles. Yet, the overall properties of the gas, made up of all of these unpredictable particles is very predictable according to the laws of thermodynamics. And the whole process of technology evolution is similarly a complex dynamic system where each individual project is unpredictable, but the overall results are very predictable. And that's another observation that is contrary to common belief.

UBIQUITY: You see yourself as basically an expert in pattern recognition, correct?

KURZWEIL: Yes, that's my field of interest. We developed the first omni-font optical character recognition system, and the first commercially marketed large-vocabulary speech recognition system. We're now working on electrocardiogram automatic diagnosis to create a smart undershirt for people with heart disease and conditions like that. So pattern recognition is my field of expertise.

UBIQUITY: And so pattern recognition is the heart of ... what? Finish that sentence.

KURZWEIL: Pattern recognition is the heart of human intelligence. We're in fact not very good at logical thinking, analytical thinking. Computers are already much better at that than we are -- as is clear if you consider a math program like "Mathematica" that's very hard even for professionals and mathematicians to keep up with. And yet people are still better than machines at recognizing patterns. However, machines are getting better, and ultimately machines will be better than humans in all areas of pattern recognition. Of course, at that point, computers will have achieved human levels of intelligence, in the late 2020s. But human pattern recognition, though, is basically hardwired for certain types of patterns. For example, there's actually a region of the brain that recognizes faces, and we're very good at that, because we have a built-in capability. We're very good at recognizing language sounds, and language skill is essentially a pattern recognition capability. Computers can apply pattern recognition principles to other types of patterns that humans are good at, and they're also learning how to do the kinds of pattern recognition that humans are *not* good at. And ultimately, we'll be able to exceed human intelligence.

UBIQUITY: Expand on the idea by using chess as an example.

KURZWEIL: In chess, a computer can do the logical thinking of thinking about all of the move and counter-move sequences and think all of the different sequences of moves 12 moves ahead and consider billions of those in a few seconds. Garry Kasparov, the chess master, was asked, "How many board positions can you think of in a second?" He said, "Well, less than one." So how is it that he can actually compete against a machine? It's because of pattern recognition. He looks at the board and just instantly recognizes a pattern. He sees: "This is like the board where grand master So-and-So forgot to protect his trailing pawn two years ago." And he's actually studied 100,000 board positions. That is how humans think, largely by recognizing patterns.

UBIQUITY: Is there some taxonomy of pattern recognition, so that you could, for example, compare the pattern recognition involved in different domains? For example, you, Ray Kurzweil, see patterns from the perspective of an inventor, whereas sports fans will see patterns in football strategies and football games.

KURZWEIL: Yes, that's a typically human observation, and is how we think: we see patterns. A better coach or sports strategist will be able to have

greater insights into those patterns, and be able to anticipate the patterns of the opposition, and then think of some way of superseding that. And historians see patterns in events in the world. Pattern recognition is the essence of what intelligence is.

UBIQUITY: Is pattern recognition, though, a generalizable talent that can be replicated and transferred? You've had an astonishing record as an inventor, and you seem to have started when you were -- what? -- age five or something?

KURZWEIL: Well, five was when I fashioned myself an inventor; I decided I was going to be an inventor when I was five, and I never really wavered from that. When other kids were wondering whether they would be, firemen or teachers, I always had this conceit, "Well, I know I'm going to be an inventor," and that never changed.

UBIQUITY: I had the same conceit but I never invented anything, so what I'm wondering now is what is the nature of your pattern recognition talent? How do you actually go about inventing things? What's the trick? Because I suspect that if you went into any environment whatsoever, you would invent something for that environment. Is that a fair assumption?

KURZWEIL: Yes, well, part of it is a belief in the power of ideas, and a confidence that I can find the ideas to solve a problem, and that these ideas exist. One technique is to just to use one's imagination. Imagine that a particular problem has been solved, and imagine what the solution would have to look like. So I'll fantasize that I'm giving a presentation four years from now, and describing the invention to my audience, and then I'll imagine what would I have to be saying, and what characteristics would the invention have to have? And then I work backwards: OK, if it's a reading machine, well it would have to somehow pick up the image of the page -- well how would it do that? And you use your imagination to break it down into smaller and smaller problems.

UBIQUITY: And this isn't a poetic conceit now? You really do work that way?

KURZWEIL: Yes, that is how I work. And I actually have a specific mental technique where I do this at night. I've been doing this for several decades. When I go to sleep I assign myself a problem.

UBIQUITY: For example?

KURZWEIL: It might be some mathematical problem or some practical issue for an invention or even a business strategy question or an interpersonal problem. But I'll assign myself some problem where there's a solution, and I try not to solve it before I go to sleep but just try to think about what do I know about this? What characteristics would a solution have? And then I go to sleep. Doing this primes my subconscious to think about it. Sigmund Freud said accurately that when we dream, some of the censors in our brain are relaxed, so that you might dream about things that are socially taboo or sexually taboo, because the various censors in our brain that say "You can't think that thought!" are relaxed. So we think about weird things that we wouldn't allow ourselves to think about during the day.

There are also professional blinders that prevent people from thinking creatively. Mental blocks such as "You can't solve a signal processing problem that way" or "Linguistics is not supposed to be done this way." Those assumptions are also relaxed in your dream state, and so you'll think about new ways of solving problems without being burdened by constraints like that. Another thing that's not working when you're dreaming is your rational faculties to evaluate whether an idea is reasonable, and that's why fantastic things will happen in the dream, and the most amazing thing of all is that you don't think these fantastic things are amazing. So, let's say, an elephant walks through the wall, you don't say, "My God, how did an elephant walk through the wall?" You just say, "OK, an elephant walked through wall, no big deal." So your rational faculties are also not working.

The next step is in the morning, in this half-way state between dreaming and being awake, what I call lucid dreaming, I still have access to the dream thoughts. But now I'm sufficiently conscious to also have my rational faculties. And I can evaluate these ideas, these new creative ideas that came to me during the night, and actually see which ones make sense. After 15 to 20 minutes, generally, if I stay in that state, I can have keen new insights into whatever the problem was that I assigned myself. And I've come up with many inventions this way. I've come up with solutions to problems. If I have a key decision to make, I'll always go through this process. And I'll then have a real confidence in the decision, as opposed to just trying to guess at the answer. So this is the mental technique I use to try to combine creative thinking with rational thinking.

UBIQUITY: What implications might your technique have for education?

KURZWEIL: Well, I do think that for kids (or really for people at any age) the best way to learn something is to try to solve real problems that are meaningful to them. If, for example, you're trying to create a reading machine, then you learn about optics. And you learn about signal processing, and image enhancement techniques and all of these different things that you need to know in order to solve the problem. If you really

have a compelling need to solve these problems, you will learn about them. If you're trying to create, let's say, a hip hop song, well you learn about the history of hip hop, and how it emerged from other forms of music. And you learn something about urban culture. So learning things in context, where you're actually trying to make a contribution yourself, is a very motivating way to learn -- as opposed to just trying to dryly learn facts out of context and without a purpose for learning them.

UBIQUITY: Since you mention music, a review of "The Singularity is Near" by Kevin Shapiro in the new Commentary magazine makes the observation that "computers can also compose music, but, aside from computer scientists, not many humans enjoy listening to it." Is that a true statement?

KURZWEIL: Well, yes and no. Computers, right now, are actually collaborating with people, and very few musicians will create music today without collaborating with machines that are doing sound enhancement, sequencing, mixing intelligent signal processing and so on. But that criticism is in the genre of observations made by commentators who believe that since computers don't have fully human levels of intelligence *today*, they never will. It's not my position that computers are equal to humans *today*; the whole point of my book is that they will have that ability *in the future*. And I make the case that by 2029 computers will be fully equal to humans and thereafter surpass them because they'll be able to combine human levels of intelligence with ways in which machines are superior. One machine will be able to have the best human skills at every area, and multiple machines will be able to share knowledge at electronic speeds. And the machines will double their intelligence every year, which is the nature of computer intelligence. I'm not saying that computers can do everything humans can do today. Computers can't pass the Turing test today, but I'm predicting that they'll be able to do it in 2029. [The Turing test, conceived by British artificial intelligence pioneer Alan Turing, suggests that if a person can not distinguish between a machine and a human simply by the answers they give to the person's questions, then the machine might be considered to be intelligent. --ed.] So the fact that there are still some things that humans can do that computers can't today is not a criticism of my case.

UBIQUITY: One of the many interesting things in your book is your collection of the most frequent criticisms that have been made of your work, and your response to those critics. I'm wondering if, as an exercise in pattern recognition, you can characterize not so much the criticisms but the critics: do you see certain kinds of people having certain kinds of responses to your work?

KURZWEIL: Well, that's a good question. I think one common motivation of some people is a misguided but nonetheless earnest attempt to defend the dignity of human intelligence: "It *can't* be the case that computers could achieve human levels of intelligence, therefore we've got to find some way in which this theory fails." And so: it can't be done because of physics; or it can't be done because of the way microtubules do quantum computing; or it can't be done because Gödel's uncertainty theorem proves that machines can't possibly do what humans can do; or it can't be done for biological reasons. All this frantic searching is done to find some reason it can't possibly be the case that machines could achieve the majesty of human intelligence. These criticisms are creative ideas drawn from various fields of science and philosophy, but they have this common motivation the ingrained belief that "it can't be so."

UBIQUITY: One of your critics called you a "materialist."

KURZWEIL: Yes, the philosopher John Searle. But I make the case that Searle's view is really much more the materialist view than mine. I mean he's saying -- and it's surprising, actually -- that consciousness is just an ordinary biological function like lactation: we don't understand what causes it yet, but we ultimately will find the cause as some basic biological function. That's actually a reductionist materialist perspective. But even if were to take what he's saying to be the case, my answer would be that, once we discover what that is, there's no reason why that can't be replicated in the machine. In fact, Searle acknowledges that a neuron is just a complicated machine; well, if one neuron is a machine, then a set of 100 billion neurons is also a machine.

UBIQUITY: So then you're not a materialist. I was a little surprised, however, that none of your critics, suggested that you are a mystic. Are you a mystic?

KURZWEIL: Well, it depends what you mean by mystic. I describe myself as a patternist, and believe that if you put matter and energy in just the right pattern you create something that transcends it. Technology is a good example of that: you put together lenses and mechanical parts and some computers and some software in just the right combination and you create a reading machine for the blind. It's something that transcends the semblance of parts you've put together. That is the nature of technology, and it's the nature of the human brain. Biological molecules put in a certain combination create the transcending properties of human intelligence; you put notes and sounds together in just the right combination, and you create a Beethoven symphony or a Beatles song. So patterns have a power that transcends the parts of that pattern.

UBIQUITY: Isn't transcendence another way of saying mystical?

KURZWEIL: Well, it could be. It is a reasonable use of the word mystical or magical, but it can have other connotations, namely that these ideas are not rooted in science and that I would disagree with. My views have come from a scientific analysis of technology trends: I didn't start with these views and then try to work backwards to justify them, I started by making a practical effort to time my technology projects, because I realized that timing actually is the most important issue in succeeding as an inventor, and so I began to study these technology trends. When I did, I discovered how predictable certain trends are, and I began making accurate predictions based on my models, which can now anticipate 10 years, 20 years, 30 years into the future, and come up with fairly dramatic scenarios of what will be feasible.

UBIQUITY: Have any of your critics caught your attention to the extent that you changed the way you think about some of these things?

KURZWEIL: That's a good question. The basic theory I put forth, the Law of Accelerating Returns, has proven out over several decades. I had hundreds of predictions about the 1990s, and the early 2000s, in my first book, which I wrote in the mid 1980s, "The Age of Intelligent Machines," which were controversial at the time but have proven to have been quite accurate. I've continued to think about the implications of this theory and we've seen how it's applicable to fields like biology, which is something that really wasn't clear 10 years ago. We only had the genome just two years ago. So I think the critics have actually illuminated various issues that need consideration to really think through the implications philosophically or in terms of different aspects of our biology. And so it's caused me to think through and develop the theory in to other realms. But I think my basic theory is correct, and I haven't changed my dates: I've been projecting the end of the 2020s for machines passing the Turing test consistently for a long time.

UBIQUITY: Someone like H.G. Wells went from science and technology into world government and large social issues and such. Have you attempted to follow his example?

KURZWEIL: Well, I am involved with one important aspect, and that is to study the downside to these technologies. I'm not a utopian, and my view is not a utopian perspective. I've been articulating the dangers and downsizing of these technologies for a long time. Are you familiar with Bill Joy's "Wired" cover story?

UBIQUITY: Yes. In fact, that was the main topic of his Ubiquity interview: <http://www.acm.org/ubiquity/interviews/b_joy_1.html>.

KURZWEIL: Right. Well, you know, he got his views originally from my book "The Age of Spiritual Machines," which came out in 1999 and from some conversations we had in 1998. I articulated the downsides in that book and in those conversations, and I articulate the dangers again in my new book, "The Singularity Is Near." Chapter Eight is "The Deeply Intertwined Promise and Parallel of GNR [GNR stands for the Genetics, Nanotechnology, and Robotics age -- ed.]." It is my view that the answer to the danger is not to relinquish these technologies -- the position advocated by Bill McKibben, a noted environmentalist who brought global warming to our attention. I have a lot of respect for him, but reject his view that we should basically stop technology progress, and say "enough is enough." In fact, his latest book is called "Enough," his position is that technology has been very good and brought us a lot of good things, but that now we have enough, and that continuing technological development is going to create too many dangers. But I'm opposed to that perspective, for two reasons. Number one is that it would deprive humanity of the benefits, which we very much need: I mean we're close to overcoming cancer and heart disease, and stopping progress will allow the suffering in the world to continue. But secondly, it wouldn't work in terms of ameliorating the dangers, and would actually make them worse, because it would drive these technologies underground where we would have even less control over them. Responsible scientists would not have access to the tools needed to defend society.

UBIQUITY: What would a good example of this be?

KURZWEIL: Software viruses. Here we have a new human-made, self-replicating pathogen that didn't exist 30 years ago, and the viruses get more and more sophisticated. Yet they have not destroyed the Internet, they have not destroyed computer networks, and we keep them at pretty much a nuisance level, because we have a technological immune system that responds to the danger every time there's some new sophisticated attack with some new virus. The defenses are created and are distributed within a matter of hours. Now if we can do half as well in the area of let's say biological viruses, or self-replicating nanotechnology, we'll be doing well. However, we do need to invest in the defensive technologies. And I've done a lot to advance that idea. I gave testimony to the Congress recently proposing a $100 billion program to create a rapid response system for new biological viruses. Some elements of that were in President Bush's $7 billion program that he recently announced. It doesn't go far enough, and is too small a program by order of magnitude, but we do have technologies like RNA interference that can actually destroy biological viruses. I proposed a

program that would rapidly sequence a new virus, create an RNA interference medication quickly, and gear up manufacturing. Within a week or two, we could respond to any new virus like bird flu, which is a natural virus, or an unnatural virus like a terrorist weapon. We don't have that system in place, but we could put it in place. And I think we should do that.

UBIQUITY: What other issues have you been involved in?

KURZWEIL: I'm on the Army Science Advisory Group. The Army is actually the institution responsible for combating bioterrorism, and I've been advising them on that. We need to increase our investment in developing the defensive technologies, because the biggest threat we have right now is the specter of a bioengineered biological virus that could be very disruptive. In fact, Bill Joy and I had a joint op-ed piece in the New York Times a few weeks ago, called "Recipe for Destruction," where we both criticized the publication on the Web of the genome of the 1918 flu virus. We pointed out that it's basically a recipe for a weapon of mass destruction. People would not advocate putting the precise design of an atom bomb on the Web -- which is in fact, illegal -- and we weren't happy when A.Q. Kahn of Pakistan was disseminating just that kind of information. Yet here we have the design of a biological weapon that could be even worse than an atomic bomb.

UBIQUITY: You call it a recipe. Is it a simple recipe?

KURZWEIL: Yes; in fact it is even easier now to create the 1918 flu from the genome than it would be to create an atomic bomb from its design. If I gave you the precise design for an atomic bomb you still couldn't build one, and even if I gave you plutonium and the precise designs you'd still have a hard time because building an atomic bomb requires some pretty exotic industrial processes. Yet if I gave you the genome of the 1918 flu (and in fact now you have it, it's on the Web, you can download it), you can send in a genetic sequence to a mail order house and get it built for you. Now I'm not saying it's completely trivial to create the 1918 flu -- it has eight genes and they have to be organized in just the right way; but it's actually not that hard either. So we criticized the publication of that information. The genome was published to provide the information to scientists who are trying to protect us from bird flu, but the alternative would have been to provide it just to those scientists, with some kind of security provisions, and that is something we do all of the time with dangerous information. So, anyway, I am involved quite heavily in these kinds of issues on the safe use of these very powerful technologies.

UBIQUITY: Now is it fair to say that in spite of your concern with the downside of many of these issues you remain basically an optimist as far as the technological future is concerned?

KURZWEIL: Yes. Part of that is just my nature, and I think you have to be an optimist to be an inventor and an entrepreneur -- because if you were aware of all of the obstacles you were going to face you'd probably never start any project. So being optimistic, I think, is actually self-fulfilling: it's not just an idle anticipation of the future. You actually change the future if you're optimistic in a positive way. But also it comes from just looking at the actual history of technology, which has done an astonishing amount of good. Although we've had a hundred wars in the 20th century, wars that killed 180 million people, you can't necessarily blame technology for creating the conflicts, even if they expanded the scale of destruction; nonetheless, despite that, I would say technology has done more good than harm. You know, 99.9 percent of humanity lived terrible lives 200 or 300 years ago, and life was well-described by Thomas Hobbes as "nasty, brutish, and short." Human life expectancy was only 37 in 1800, and if someone got a simple bacterial infection it would plunge that person's whole family into desperation, because there were no social safety nets. Life was extremely difficult, and labor-filled. For example, it took six hours to prepare the evening meal. So we have liberated ourselves to a great extent from these kinds of miseries. Though we still have a lot of suffering in the world, only technology has the scale to solve problems like environmental degradation and poverty. And the trends are very positive in that. We wiped out half of poverty in Asia over the last 10 years. According to the World Bank, at current rates, we'll cut poverty rates by 90 percent in the next 10 years in Asia, and other areas of the world have also made progress. So I am optimistic, even though I am mindful of these downsides.

UBIQUITY: Do you have any thoughts about globalization, and the anti-globalization resistance movement?

KURZWEIL: Well, globalization is a reflection of the fact that the Internet is a worldwide phenomenon and has nothing to do with national boundaries. A whole economy exists in this virtual world, which is becoming a larger and larger portion of the world economy. The power, and bandwidth, and reach of this virtual world is growing exponentially, so the idea of, let's say, stopping outsourcing is like trying to sweep back the ocean. I think there is a strong anti-technology movement that started with the Luddites in 1800. I think that movement is fundamentally misguided, because it fails to appreciate the profound benefits technology has brought. For example, the anti GMO movement has forced African nations to refuse food aid because the food has been genetically modified -- and golden rice, which can save

hundreds of thousands of children from going blind, has been blocked because it involves genetically modified crops. I'm not saying necessarily saying that every GMO [genetically modified organism -- ed.] is automatically safe, but the idea that every GMO is automatically detrimental to the world is just plain wrong.

UBIQUITY: Do you think the new Luddites will ever come to see the light?

KURZWEIL: I think they're going to continue doing what they're doing: trying to stop progress and trying to keep human beings the way they are. But if you ask me what is a human being, I'd say that we are the species that seeks to go beyond our limitations and beyond our boundaries. We didn't stay on the ground. We didn't stay in the planet. We didn't stay within the limits of our biology. And I would point out that, if it were up to the Luddites, human life expectancy would still be 37, and we'd still be dying from bacterial infections.

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