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Edge City: Life on the New Frontier

The Nine Nations of North America

Radical Evolution

The Promise and Peril of Enhancing Our Minds, Our Bodies—and What It Means to Be Human

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CHAPTER FOUR

Heaven

Nature, Mr. Allnut, is what we are
put in this world to rise above.

—Katharine Hepburn, in John Huston's
The African Queen, 1951

We are as gods and might as well get good at it.

—Stewart Brand, in the statement of purpose of
The Whole Earth Catalog, 1968

WELLESLEY, MASSACHUSETTS, is a crucible of the past and future. This stately village is not far from the gritty cities of Rhode Island and Massachusetts where modern America began. In those places, starting in 1793, waterfalls powered the continent's first textile mills, launching the Industrial Revolution in the New World.

Wellesley today is just outside the fabled Route 128 corridor, where, in the 1950s and 1960s the Information Age arose. That circulator highway curves west around the great research centers of Boston and Cambridge—especially the Massachusetts Institute of Technology. In low-rise office campuses that MIT researchers built for their companies along Route 128, the world's high-tech revolution blossomed. In fact, at one point, if one of these fellows came to the First National Bank of Boston to ask for money and he had a government contract associated with a high-technology scheme, the loan officers had standing orders: No matter how crazy either this person or his idea seemed, neither could be turned down without authorization from a senior vice president.

Wellesley is also just south of Walden Pond, where, starting in 1845, Henry David Thoreau lived for two years and two months in a 10-by-15-foot hand-crafted cabin, considering the prospects for human transcendence. In his book *Walden, or Life in the Woods,* he came to the studied conclusion that "men have become the tools of their tools."

Now the Route 128 area is as much an incubator of biotech as of information technology, creating new opportunity and wealth. That's why the village of Wellesley today is the sort of idealized spot where the 18th century meets the 21st. Wellesley is a place where emporia don't so much sell sandwiches as offer "savories." Shop windows are full of marvelously slinky dresses, without price tags, aimed at those who timed their stock options right. There are an impossible number of art galleries and sophisticated craft shops with names like The Gifted Hand. Wellesley is the kind of place where the sidewalks are accented by brick and are cleaned more often than some kitchen floors. The tavern of the old Wellesley Inn on the Square is called Brix° 576. Brix° with that little degree symbol is a measure of the sugar content in the juice of wine grapes before it is fermented. In parts of Silicon Valley, too, such as Burlingame, you can see a lot of this crafted balance between old and new—between greensward and gigapixels. Wellesley has taken to heart the words of Alan Kay, the father of the mouse-driven, point-and-click computer desktop, when he said, "The best way to predict the future is to invent it yourself."

Not far from this village, predicting the future by inventing it himself is clearly what Ray Kurzweil is up to. A two-lane blacktop named Walnut Street, as it nears an on-ramp to Route 128, crosses the Charles River. In a dozen miles the broad Charles will define Boston and Cambridge. But here it is easily spanned by an ancient stone bridge as it burbles on its way to a waterfall that once powered one of those venerable textile mills. Between the bridge and the dam today is an isolated office building with marvelous river views from three sides. The office building demonstrates that the future still needs a little work. It offers a shockingly butt-ugly example of how badly precast concrete exteriors can age. This is the headquarters of Kurzweil Technologies.

In the lobby of the second floor, where Kurzweil has his office, is a museum-worthy Ediphone, created by Kurzweil's hero, Thomas Edison. Billed as a "Voice Writer," the Ediphone was produced by the Edison Company in the 1920s. It has a tube you speak into the size of a powder horn. It was the world's first mass-market business dictation device, transforming speech into electrons and then back into speech. As Edison famously said, "I find out what the world needs. Then I go ahead and try to invent it."

Not far away is an equally museum-worthy Kurzweil Reading Machine from the 1970s. It goes the Ediphone one better. It can read out

loud any book on your shelf. It looks like a photocopier that can talk, which is basically what it is. You lay the open book down on the scanner. Presto—the mechanical voice reads it to you. It is the first consumer device to use artificial intelligence. To be able independently to read books not published in Braille was a huge breakthrough for the blind. Kurzweil sold the first one to Stevie Wonder.

A minion demonstrates the old machine to me, laying a printed copy of the Gettysburg Address on its platen. "Four score and seven years ago," the mechanical voice promptly starts. Then it gets to the word *liberty*. "Li-bah-dee," it says. Still a few bugs in the system—the machine has a Boston accent.

When Kurzweil was in high school in 1965, he appeared on the hit television show *I've Got a Secret*, in which celebrity panelists attempted to puzzle out a guest's mystery. Kurzweil sat down on an old upright piano and played a composition. Then he whispered to Steve Allen, the show's host, "I built my own computer." "Well, that's impressive," Allen replied, "but what does that have to do with the piece you just played?" Kurzweil then whispered the rest of his secret: "The computer composed the piece I just played."

This primitive machine, which analyzed the work of famous musicians and then created new melodies in the same style, was Kurzweil's first foray into that core part of human thought so difficult for computers to match: pattern recognition.

Soon after college, Kurzweil developed three technologies. He invented the first practical flatbed scanner, launching a multibillion-dollar industry. He invented the character recognition device that could read any typeface, not just those weird ones that were designed specifically for computers. And he invented the first full text-to-speech synthesizer. Together, these brought the Kurzweil Reading Machine to life. When he unveiled his device, revered news anchor Walter Cronkite, on the air, had the machine read his signature sign-off: "And that's the way it was, January 13, 1976."

Kurzweil has created nine technology companies that continue to be leaders in their fields. One was built around the Kurzweil 250. Invited by Stevie Wonder to deliver an encore to his reading machine, Kurzweil invented the first music synthesizer that could match the response of the grand piano and other orchestral instruments. It is so realistic that most musicians can't tell the difference. Because it can create the sound of a universe of instruments, the 250 allows a teenager in her bedroom to

imagine music for a rock band or an entire philharmonic, hear what her composition sounds like, and instantly revise it if she doesn't like it. It is now marketed in more than 40 countries.

Another company is Kurzweil Applied Intelligence, which was the first to commercially introduce large-vocabulary speech-recognition systems. By the early 21st century, doctors in 10 percent of American emergency rooms were already talking into them and seeing their notes transformed into print. Kurzweil's latest venture is the whimsically named FAT KAT (Financial Accelerating Transactions from Kurzweil Adaptive Technologies). It applies pattern recognition to stock market decisions. Its goal is to create an artificially intelligent financial analyst—which certainly sounds like an improvement.

In the course of all this Kurzweil has received a raft of decorations. He has been granted the National Medal of Technology, the nation's highest such award. He's been inducted into the U.S. Patent Office's National Inventors Hall of Fame. He was named Inventor of the Year by MIT and the Boston Museum of Science. Three U.S. presidents have honored him. The music industry and the handicapped have showered him with prizes. He's received eleven honorary degrees.

But that's not what made Kurzweil notorious.

His books are what really curl people's toes. In *The Age of Intelligent Machines,* Kurzweil in 1989 predicted the World Wide Web, the taking of the world chess championship by a computer, and the dominance of intelligent weapons in warfare. All of this seemed pretty far-fetched at the time. Yet in 1999, in *The Age of Spiritual Machines: When Computers Exceed Human Intelligence,* which has been translated into nine languages, Kurzweil went much farther than that, predicting that in a very few decades, because of The Curve discussed in the previous chapter, many intelligences will roam the earth that are not traditional humans. His 2005 work, *The Singularity Is Near: When Humans Transcend Biology,* tops that, however. It lays out the case for the imminent and cataclysmic upheaval in human affairs associated with The Singularity.

But even that isn't the audacious part.

What makes Kurzweil an outrage to some and an inspiration to others is that he is relentlessly and fiercely optimistic about these futures. He uses charts and graphs to systematically portray a near future that to some seems indistinguishable from the Christian version of paradise. On top of everything else, he is convinced that medicine is moving sufficiently fast that any person who can stay healthy for the next 20 years may so benefit

from the explosion in biological technology as to be immortal. He lays out an extensive scientific, nonreligious, non–New Age case for personally planning to live for a thousand years. When challenged, he doesn't retreat from his logic at all. Once, to rattle his cage, I paraphrased the author Arthur C. Clarke's renowned line, "Any sufficiently advanced technology is indistinguishable from magic." I asked him, So, Ray, what are you saying? That any sufficiently advanced technology is indistinguishable from angels? He did not back off an inch. "Depends on what you mean by angels," he replied.

I call his scenario Heaven.

When we met in his office one bright, brisk New England April day, I delicately inquired, So, Ray, Do you have enough cash to last the next thousand years?

"Probably not," he replied unflappably, and without a trace of irony. "I can support my family and some businesses. I mean, capital to an entrepreneur is kind of like clay to a sculptor. So I can experiment with inventions and ideas, which is a nice freedom to have. But I think I'll need a bit more for a thousand years, particularly with the way things are going to speed up."

Raymond C. ("for Clyde—please don't put that in") Kurzweil is a first-generation American, born in 1948. His parents were refined Viennese Jews. His mother's father was a leading physician, a friend of the Freuds. He got the family out in 1938, one step ahead of Hitler. Kurzweil's mother, Hannah, is a gifted artist. A remarkable painting of hers, of flowers, hangs on Kurzweil's office wall, right next to a remarkable painting created by a computer, also of flowers. His late father, Fredric, a brilliant musician, had been Hannah's music teacher in Vienna. Just before the Holocaust, a wealthy American society woman who was a patron of the arts brought him out of danger. He joined the U.S. Army and ended up as musical director at Fort Dix, where he and Hannah had a reunion, a quick courtship and a military wedding.

Until Kurzweil was six, his family lived the life of struggling artists in one of America's first "garden apartments," a walk-up in Jackson Heights, in western Queens, New York. Jackson Heights was then a lower-middle-class Irish and Jewish quarter, different in flavor from today's polyglot neighborhood of Indians, Bangladeshis and Pakistanis as well as Colombians and Ecuadorans. Those immigrants are overlaid on the community of elderly Jews still living there. All are being joined by the urban hip moving into those same old newly trendy garden apartments.

Fredric Kurzweil became conductor of the Bell Symphony, performing at Carnegie Hall, and was chairman of the music department at Queensborough College. (Kurzweil recalls that when his father wrote a symphony, he had to rent a hall, hire all the musicians and write out all the sheet music for each of them just to hear what he needed to change. The son wishes his father had had a Kurzweil 250.) The family eventually moved to a nice brick middle-class house. Ray Kurzweil attended Martin Van Buren High School, a vast public school with 2,000 students per grade and a science program that produced more Westinghouse award winners than any other high school in the country at the time—even surpassing the Bronx High School of Science, no small boast. Kurzweil didn't take school terribly seriously, but he fondly recalls several mentors who validated his notion that imagination was not incompatible with science.

Several forces shaped his attitudes toward human frailty. One was the tragedy born of human nature that was the Holocaust, uprooting his family as well as destroying much of his wife's. Another was his father's medical history. The elder Kurzweil had a major heart attack when he was 51—four years younger than was Kurzweil at the time of our conversation. The elder Kurzweil died at 58. Kurzweil himself was diagnosed with Type II diabetes when he was in his 30s. He brought it under control, he says, by a very aggressive program he researched and designed himself, involving lifestyle, nutrition and supplements. He now takes 250 pills a day. When Kurzweil was younger, he grew accustomed to being told he resembled the musician Paul Simon, of Simon and Garfunkel fame. He has seriously reduced his body fat since then, so at the time of the interview, he had the sort of deeply lined, sad and wizened visage that you might expect of a man in his mid-50s whose face used to be much fuller. He looked like a cross between Paul Simon and a basset hound.

What Kurzweil really worships is ideas. "Religion in my household was ideas and knowledge," he says. "I remember my grandfather telling me that he was allowed into a special part of a library and was actually able to handle some of da Vinci's original documents. He described it in reverential terms, like it was a religious experience, like he handled the Ten Commandments. And what is the significance of da Vinci's documents? They were ideas. Ideas that were different, that defied the current common wisdom. He just gave free rein to his imagination. Things like the airplane."

Kurzweil's formal religious upbringing was eclectic. He still belongs to a Reform temple. "I see Judaism as a cultural identification. It's one I'm proud of, because Jews have been pioneers, from Bob Dylan to Einstein to Freud. Jews are very often in the forefront of democratic movements and the rights of women, and things like that."

His parents, however, "wanted to avoid the provincialism of the narrow religions," as he says they saw it. So the family joined a Unitarian church. "In keeping with the power of ideas, my own religious education was in a Unitarian Sunday school. The theme of this educational program was 'many paths to the truth.' We would spend six months studying a particular religion—let's say Buddhism. We would go to those services, we'd study those books and bring Buddhist religious leaders into our discussion group. Some of the kids took it more seriously than others. But I actually was one of the more involved."

What he learned was that "seemingly different stories are really speaking the same truth. The theme was tolerance of different ways of looking at things, and that was also very influential. The real truth of the matter is something that can transcend an apparent contradiction. We see that in physics. Is light a particle or a wave? Both are true, even though they seem to contradict each other."

Today his is a "Buddhist's view of God—as the sort of life force, the force of creativity. As opposed to a specific cranky personality that makes deals with humanity and gets mad and exacts vengeance."

This worship of a life force fuels his optimism about the coming transcendence of human nature. "What we see in evolution is increasingly accelerating intelligence, beauty. We find evolving organisms, like humans, that are capable of higher emotions like love. I mean, if you go to the point where there were just reptiles, there was no love. They don't have much emotional intelligence. They don't have art, music. So part of the evolutionary process—and this has continued with our technological growth of human cultural and technological history—is an increase of those higher emotional, intelligent functions. We see exponentially greater love.

"Even 200 years ago, 98 or 99 percent of human beings lived lives of utter desperation. Extreme poverty. Extreme labor. Spending all their time to prepare the evening meal. Extremely disaster-prone. No social safety nets. Now at least an increasing portion of human civilization is free of that level of desperation. So our ability to appreciate arts and music and to have stable relationships is increasing. That was relatively difficult to do even 200 years ago, let alone thousands of years ago."

The core element of Kurzweil's thinking is that The Curve of exponentially increasing technology is rising smoothly, as if on rails. It is in command, in his view, and unstoppable. Everything flows from that. He sees The Curve as a force of nature. He sees it as an extension of evolution. He does not particularly see The Curve as something humans chose to create. Like evolution, it is simply a pattern of life to be recognized, the outcome of billions of small actions. He calls it "The Law of Accelerating Returns." In his view, nothing any one country or collection of countries can do will deflect it or even slow it down. Forget oil shocks or climate change. The only possible limit he sees is a complete and catastrophic collapse of civilization or the extinction of the human species, worldwide, and he only inserts that as something of a rhetorical footnote.

"Exponential progress, in recent times, has marched right through" disasters such as the Depression and World War II, he observes. "It really is an evolutionary process. Biological evolution is full of unpredictable events like visitors from outer space in the form of meteors and asteroids. But nonetheless, out of that chaos comes a very smooth curve. Now the progress is so rapid that The Curves are on a very fast track. But they still emerge from an evolutionary process that is full of disruption. I mean, a lot of people ask me, 'Well, now with 9/11 things must be different? Or with the high-tech recession and the meltdown of communications and Internet stocks, surely that has disrupted these curves?' "

Well, no they haven't, Kurzweil says.

"These meltdowns were only meltdowns in the capital markets—they don't affect the fundamental issues that are driving this progress. We get more powerful tools. We use the more powerful tools to create the next generation. That is built into our economic expectations. A company, even to survive or tread water, has to move ahead. The perception that Wall Street had, that telecommunications and the Internet were revolutionary, was correct. But that does not mean there is not a pace to these things. Investment got ahead of itself. They overinvested in one aspect of the technology, like fiber, and underestimated other aspects. So the capital market suffered. But the actual technologies have proceeded. You can see very smooth exponential growth with the boom or the bust, even though every point on those curves is a human drama of competition and marketing programs and bankruptcies and initial public offerings. So you'd think it would be very erratic. But it's not. It is very smooth. Now, those curves are moving very quickly, so the underlying chaos is happening very quickly."

I ask Kurzweil what he thinks of scenarios that are very different from his, such as the ones in the ensuing chapters of this book: Hell, in which the technology is used for extreme evil, threatening humanity with extinction, and Prevail, in which humans shape and adapt it in entirely new directions.

He can't see these scenarios. "I mean, you go to these academic conferences and they talk as if we could get some consensus and stop these processes. 'Let's keep those good technologies, but those dangerous ones, you know, like nanotechnology—let's just not do those.' How unrealistic that is. Nanotechnology is not just one thing or three things. It is really the end result of miniaturization, which is pervading all of technology. Most technology will be nanotechnology in the 2020s. You would have to relinquish all of technology."

Kurzweil shrugs at the controversy over the use of stem cells from human embryos, for example. "All the political energy that has gone into this issue—it is not even slowing down the most narrow approach." It is simply being pursued by others outside the United States in places such as China, Korea, Taiwan, Singapore, Scandinavia and Great Britain, where scientists will probably get there first, he notes. He compares political obstacles to boulders thrown into a stream—the water just flows around them, although he does acknowledge that such political boulders can divert the flow. In the case of stem cells, the ethical problems involved in destroying human embryos, he believes, may hasten research that will allow any cell—such as your own skin cell—to be redirected to form any other kind of cell, maybe a nerve cell. "I'd rather have my own DNA anyway," he says.

Kurzweil has heard all the arguments. What about the notion that people will simply recoil from a technoid future? He's impatient with that. "Your quintessential grandmother uses her cell phone and she calls up British Airways and makes reservations with a virtual reservation agent"—a computer that understands your speech and talks back intelligently. "We don't have to be experts."

Perhaps most important to his notion that The Curve is unstoppable is that he sees it as a voyage of tiny advances. "Each application is a relatively small, noncontroversial, benign step. If you have a better way of diagnosing something, or more effective treatment, it's not controversial. It is just readily accepted. We get from here to these more revolutionary scenarios through a hundred steps like that."

Kurzweil is incensed that more scientists and technologists are not

taking seriously their moral responsibility to raise their hands if they think they are looking at developments that will add up to profound transformation.

"Scientists are absolutely trained not to think about this. It is just part of the scientific style, or ethic, to be very conservative about what you are trying to do. A typical scientific speech is, 'We know very little about XYZ, we have just begun to scratch the surface, our ignorance is far more than our knowledge, we don't know this and we don't know that, and maybe, with luck, we'll be able to shed some light on what I am now working on, and anything beyond that is sheer speculation.'

"Well, that was all very well and good when a generation of that kind of technology was 20 years. But now when a generation is more like 2 years, society does have an interest in knowing what is going to happen 3, 4, 5, even 10 generations away. Yet scientists typically are trained not to speculate beyond maybe one or two generations of technology and science. So, hence, they very often take a ridiculing attitude towards the future and bring up wrong predictions from the past—that were made without any methodology. They just dismiss the whole idea of looking ahead. But that is not of service to society. I mean, even though we can't be absolutely sure what is going to happen and how these scenarios will play out, these basic trends are so strong—we need to appreciate their existence. They really do reflect a future that is going to be very different. I have tried to bring some disciplined approach to studying these trends, and it is something where I have actually some track record."

Kurzweil, for example, points to his 1989 prediction in *The Age of Intelligent Machines* of the collapse of the Soviet Union. It may seem obvious in hindsight, but in 1988, the U.S. Central Intelligence Agency averred that that regime would be America's principal foe through the lifetimes of our children and our children's children. Kurzweil, by contrast, saw the Soviets' dilemma. "Either they would support these decentralized technologies, which would ultimately destroy how tight a control they would have, or they would avoid them—as they tried to relinquish, say, photocopiers—in which case they would destroy their economy and ultimately fail. I actually predicted that they would do a little bit of both and both would do them in, and I think that is exactly what happened."

Even the rapid, peaceful, and complete collapse of the Berlin Wall and the five-decade-long Cold War is less breathtaking than Kurzweil's predictions for the near future. Those are about technology entering our bodies and our brains, fundamentally transforming us.

In *The Age of Spiritual Machines,* written in 1998 and published in 1999, Kurzweil went way, way out on the proverbial limb. He did something popular Nostradamus-style "futurists" always avoid: He predicted not only what he thought would happen but also when. He did so unambiguously, with specific numbers, and in print. He made clear his methodology in ways others could replicate and critique—which they certainly did. In 2001 he opened an award-winning Web site, www.kurzweilai.net, complete with a daily e-mail newsletter on which is posted papers and news reports that address the possibilities that his predictions might be right or wrong. He even collaborated on a book of essays by some of his most scathing critics—*Are We Spiritual Machines? Ray Kurzweil vs. the Critics of Strong AI,* albeit one in which he gets to comment on their challenges. Kurzweil majored in creative writing as well as computer science at MIT. (By the end of his sophomore year, he'd taken all the computer science classes MIT had to offer. There weren't that many of them in 1967.) One suspects that the skills he picked up helped gain him a much wider audience than his peers who languish in the sometimes difficult-to-plow-through ghetto of science writing. Kurzweil became the John the Baptist of the technologists, offering broad and striking visions of the future. Even those who disagree with him are forced to acknowledge their debt. As you will see in the next chapter, he cleared the way for Bill Joy, the former Sun chief scientist, to get so agitated that Joy felt compelled to publish his Hell Scenario.

In his narrative describing the end of the first decade of the 21st century, Kurzweil portrays a world in which individuals primarily use computers that are portable, as many as a dozen of which are commonly worn as wristwatches, rings, earrings, eyeglasses and clothing. They provide services previously associated with cell phones, personal digital assistants and credit cards. But they also provide directions, play games and allow you into secure buildings. Keyboards still exist in Kurzweil's 2009, but the majority of text is created by devices that recognize speech. Many commercial transactions—such as purchasing gasoline at a 7-Eleven—are conducted with an animated personality. That is to say, the gas pump has a face and a voice. Supercomputers match the estimated hardware capabilities of the human brain—20 million billions of calculations per second. An ordinary $1,000 personal computer can perform about a trillion calculations per second. Children learn to read on their own, using their personal computers, before grade school. Synthetic voices sound fully human. Persons with disabilities—the deaf, the blind and

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the lame—are rapidly overcoming their handicaps through intelligent devices. Telephones that translate languages are common, though still buggy. Sexual experience at a distance—with other flesh-and-blood people as well as synthetic computer-generated virtual partners—is emerging but is not great. Intelligent assistants with animated personalities routinely assist with finding information, answering questions and conducting transactions. Both males and females prefer female personalities for their computer-based intelligent assistants. "The two most popular are Maggie, who claims to be a waitress in a Harvard Square café, and Michelle, a stripper from New Orleans. Personality designers are in demand, and the field constitutes a growth area in software development," Kurzweil writes.

Work groups are dispersed. People are successfully working together despite living in different places. The average household has more than a hundred computers—which is to say chips—most of which are embedded in appliances, entertainment and telephone systems, automobiles and even key chains. (Remember, Kurzweil is predicting this for 2009. Count the number of tiny colored lights in your household.) Household robots have emerged but are not yet fully accepted. Intelligent roads are in use, Kurzweil predicts, primarily for long-distance travel. They allow you to sit back and relax after your car's smart cruise control locks onto the control sensors. Local roads, though, are still predominantly conventional. Privacy has emerged as a major political issue. There is a growing anti-technology neo-Luddite movement. There is continuing concern with an underclass that has been left behind by a lack of skills, although the size of this underclass appears to be stable, since most people seem to be keeping up. Most visual art—especially performance art, photography and video—is a collaboration between humans and their software. Human musicians routinely jam with computer-generated musicians. Those who wish to create music no longer absolutely need fine finger coordination, the kind you see in traditional pianists and guitarists. There is a surge of interest in new "air" controllers, in which you create music by moving your hands, feet, mouth and other body parts. Virtual realities are convincing in terms of what you see and hear, although transmitting the sense of touch is still rocky. In fact, the creation of virtual reality environments is a form being addressed by artists. Wars are decided by those who have the best and most secure computers, Kurzweil predicts. Most conflicts are not between nations but between nations and terrorists. The greatest threat to national security comes from bioengineered weapons.

Cancer and heart disease mortality is being reduced by bioengineering. There is serious speculation as to whether computers will ever be conscious, like humans.

Phew.

Okay, then comes Kurzweil's narrative for the end of the second decade of the century—2019. In this prediction, based on The Curve, computers are largely invisible. They are embedded everywhere—in your walls, tables, desks, clothing and body. People generally communicate with them the way they might with a human assistant—through speech, gestures and facial expressions, which the computers recognize and respond to, as in the Steven Spielberg film *Minority Report*. Keyboards are rare, as are connecting cables. Phone calls routinely include high-resolution three-dimensional moving images piped directly into the eye. They can fool people into thinking a person is physically present. Automated language translation is high-quality and common. Some manufacturers use nanotechnology to assemble objects one atom at a time, like masons laying bricks, but that process is still not widespread. Paper books and documents are rare, since handheld displays are about the size, weight and resolution of a magazine. Adult human workers spend the majority of their time acquiring new skills and knowledge.

In Kurzweil's 2019, it is difficult to tell if a person might be blind, deaf or paraplegic because of the way computers have been so completely integrated into the body. As a result of sophisticated brain scanning, significant progress has been made in understanding how the human brain works, and that has been translated into how machines work. The price of a computer with the same raw power as a human brain is $4,000 in 1999 dollars. Of the total computing capacity of the human race—all human brains, plus all the technology the species has created—10 percent is nonhuman.

You can do virtually anything with anybody regardless of physical proximity. The technology to accomplish this is easy to use and ever-present, since it does not require any gear that is not normally worn or implanted. Household cleaning robots finally work. The vast majority of commercial transactions include a simulated person with high-quality animation and understanding of language. Often, no human is involved in this transaction at all; it's common for the human to have asked his automated personal assistant to, say, book the reservation. Transportation fatalities are rare because of the intelligence in both cars and highways. Violent crime is also down because of tiny cameras everywhere. Privacy

is a difficult thing to come by. Kurzweil is reminded of Phil Zimmerman's line. Zimmerman created the leading encryption software of the early 21st century, Pretty Good Privacy: He once said, "In the future, we'll all have fifteen minutes of privacy." This turned on its head Andy Warhol's line from the 1970s that in the future, "every person will be world-famous for fifteen minutes."

The personality of their intelligent assistant is something people spend a lot of time crafting. You can model it on actual persons, including yourself, a rock star or the secretary of state. Or you can create a personality that, like characters in a work of fiction, combines traits. In fact, people are beginning to have relationships with their automated assistants, who serve as companions, teachers, caretakers and lovers. These assistants are not yet regarded as equal to humans in the subtlety of their personalities, although there is disagreement on this point. After all, automated personalities are superior to humans in some ways—they have very reliable memories, and their responses are not governed by wildly unpredictable hormonal fluctuations.

In 2019, "an undercurrent of concern is developing with regard to the influence of machine intelligence," Kurzweil writes. "There continue to be differences between human and machine intelligence, but the advantages of human intelligence are becoming more difficult to identify and articulate. Computer intelligence is thoroughly interwoven into the mechanisms of civilization and is designed to be outwardly subservient to apparent human control." Humans are required by law to take responsibility for the actions of their machine-based intelligences. On the other hand, few decisions are made without consulting them. The life processes encoded in the human genome are now understood, including those that underlie aging, cancer and heart disease. As a result, life expectancy, which has marched steadily upward since the 1800s, continues to rise. It is now over 100. Virtual artists in all of the arts are emerging and are taken seriously. These machine artists, musicians and authors usually collaborate with humans who have contributed to their knowledge base and techniques. However, interest in their output has gone beyond the mere novelty of machines being creative.

The primary threat to security comes from small groups combining human and machine intelligence using unbreakable encrypted communications. Their weapons of choice are software viruses and bioengineered disease agents. Most flying weapons are tiny—some the size of insects. Kurzweil imagines having a conversation about security with a 2019 person, Molly. Molly reports, "It's true that the century so far has seen much less bloodshed. But the other side of the coin is that the technologies are so much more powerful today. If something did go wrong, things could spiral out of control very quickly. With bioengineering, for example, it feels a little like all ten billion of us are standing in a room up to our knees in a flammable fluid, waiting for someone—anyone—to light a match."

Kurzweil replies, "But it sounds like a lot of fire extinguishers have been installed."

"Yeah, I just hope they work," Molly replies.

Now comes Kurzweil's 2029. This is about the time that those who follow The Singularity expect it to kick in, and Kurzweil comes close. But note how Kurzweil's predictions, for all their breathtaking change every ten years, are still essentially incremental. They all seem natural and obvious to those who are experiencing them.

In 2029, says Kurzweil, a $1,000 unit of computation—one hesitates to call it a computer, because how can you tell where one leaves off and another begins?—has the hardware capacity of 1,000 human brains. (That is 20,000,000,000,000,000,000 calculations per second—20,000 million billion.) Of the total computing power of the human race—all human brains plus all the technology that the species has created—more than 99 percent is nonhuman. Remember, this is a mathematical projection of The Curve into the near future. It is easily within the lifetime of most people reading this book.

The architecture of the human brain has been much more difficult to decode than had been expected at the turn of the century, says Kurzweil about this 2029. Nonetheless, many areas of the brain are now understood. This knowledge has been used to create the computers of the day. That's why networks modeled on the brain's neural activity are substantially faster, more powerful and more capable of remembering than is the human brain. People have implanted in their eyes—either permanently or in something like contact lenses—the ability to see three-dimensional computer-generated images in addition to whatever is in front of them (handy for conference calls). Ear implants commonly provide communications both ways to the Web, in addition to helping people hear. Mind implants allow you to trade thoughts with computers. You can buy all the long-term memory and reasoning you want. It is not yet possible to download knowledge directly, however. Learning still requires time-consuming human experience and study. This is how humans spend most

of their day. Automated agents, meanwhile, are learning on their own without being spoon-fed by humans. Computers have read all available human and machine-generated literature. Significant new knowledge is created by machines, which, unlike humans, easily share knowledge with each other.

It is as hard to tell if a person is physically handicapped as it is to guess his original hair color. Everything from nerve stimulation to intelligent prosthetics makes blindness, deafness and paralysis as quaint as whooping cough. In fact, most people use devices originally aimed at the disabled. Neural implants allow family members to sit around the living room enjoying one another's company without being physically proximate. The human population has leveled off at 12 billion people. The economy continues to boom. Basic necessities of food, shelter and security are available for the vast majority of the human population. There is almost no human employment in manufacturing, agriculture and transportation. Human and nonhuman intelligences are focused on the creation of knowledge. The largest profession is education.

Aging has slowed dramatically. Most diseases can be prevented or reversed. Drugs are individually tailored to an individual's DNA, so there is nothing like the 100,000 annual deaths even from properly used prescription drugs that had been common in the United States. Robots the size of blood cells—nanobots, as they are called—are routinely injected by the millions into people's bloodstreams. They are used primarily as diagnostic scouts and patrols, so if anything goes wrong in a person's body, it can be caught extremely early. The nanobots also serve as an early warning system against bioengineered pathogen attacks. To a more limited extent, they are used as repair agents in the bloodstream and as building blocks for organs built from scratch. Life expectancy is now around 120 years. Fifty-year-olds look like 35-year-olds did in the year 2000. Significant attention is being paid to the psychological ramifications of a substantially increased human life span. Continuing extensions to the human life span will involve further use of bionic organs, including portions of the brain.

A sharp division no longer exists between the human world and the machine world. Machine intelligence is derived from the design of human intelligence, and human intelligence is enhanced by machine intelligence. Through neural implants of computer hardware into the brain, humans have greater understanding, memory and perception than ever. At the same time, many machines have personalities, skills and knowledge

derived from the reverse engineering of human intelligence. In either case, the implants mean that human intelligence is popped directly into machines and vice versa.

Defining what constitutes a human being is a significant legal and political issue. It is difficult to cite human capabilities that machines can't match. For reasons of political sensitivity, machine intelligences generally do not press the point of their superiority. The rapidly growing capability of machines is controversial, but there is no effective resistance to it. Humans realize that disengaging the human-machine civilization from its dependence on machine intelligence is not possible. Since machine intelligence was initially designed to be subservient to human control, it has not presented a threatening face to the human population. Discussion of the legal rights of machines is growing. Those not embedded in a human brain are independent. Many of the leading artists, for example, are machines. These artists say they are conscious and have as wide an array of emotional and spiritual experiences as their human progenitors. These claims are largely accepted.

Molly is Kurzweil's foil. She is his alter ego—"the woman I would want to be," he says. Molly reports from the year 2029 that she is having an affair with her personal assistant. "George is a different person every day," she says admiringly. "He just grows and learns constantly. He downloads whatever knowledge he wants from the Web and it becomes part of him. He's so smart and intense, and very spiritual." It also turns out that George, because of mind-machine sensory inputs, can make Molly smile in every possible way.

"I'm awfully happy for you," the Kurzweil character says. Then he thinks of Molly's husband. "But how does Ben feel about you and George?" he asks.

"He wasn't too crazy about it, that's for sure," replies Molly.

"But you've worked it out?"

"We've worked it out, all right. We broke up three years ago."

Put Kurzweil's 2029 in context here. Suppose you decide to go out and buy a new home today. The year 2029 will come well before you pay off your 30-year mortgage. If you have a newborn child, this is the world Kurzweil says she will be entering before she is old enough to get her medical degree.

After Kurzweil finishes describing the world of 2029, he really torques out. He takes his inexorable Curve logic out to 2099. If nothing else, his predictions demonstrate what happens when you claim expo-

nential acceleration will never level off. In this view, the change encountered over the course of the 21st century has been like ten centuries in one.

In this world, humans exist who are machine-based. They no longer have neurons, flesh or blood. They don't have "wetware." Instead, their brains are based on electronic and photonic equivalents. That's because the human brain has been reverse-engineered. It has been fully scanned, analyzed, understood and translated into machine analogues.

In Kurzweil's 2099, these "software-based humans" vastly exceed in number those still using native neuron-based brains for their thinking. Such a software-based human is not dependent on a physical body. Whenever and however they want, they can create a physical presence either through virtual reality or by creating the kind of reconfigurable nanobot swarms that Michael Crichton wrote about in his novel *Prey*, set in his usual day-after-tomorrow near-present. In this world, even those human intelligences still using carbon-based neurons plentifully augment how they think, feel, see and sense. "Humans who do not utilize such implants are unable to meaningfully participate in dialogues with those who do," Kurzweil writes. People in the early 21st century without e-mail got left out of a lot of conversations, too.

In his dialogue with the Molly of 2099, Molly acknowledges, "The spiral of accelerating returns lives on."

"I'm not surprised," responds the Kurzweil character. "Anyway, you do look amazing."

"You say that every time we meet."

"I mean you look twenty again, only more beautiful than at the start of the book."

"I knew that's how you'd want me."

"Great, now I'm going to be accused of preferring younger women."

"My body right now is just a little fog swarm projection. Neat, huh?"

"Not bad, not bad at all. You feel pretty good, too."

"I thought I'd give you a hug, I mean the book's almost over."

"This is quite a technology."

Molly has transcended. She has become essentially indistinguishable from the Christian portrayal of angels. She no longer has a permanent physical body. She can, however, project a material or virtual body at will, as she did to hug the Kurzweil character and dazzle him with her beauty. Bit by bit, over the years, everything that makes Molly herself was scanned into the larger knowledge base of human creations. There is no

distinction any longer between humanity and its creations. As a result, Molly is immortal. She has, in Kurzweil's words, gone over to the other side. She has become pure knowledge.

Kurzweil introduces the idea of MOSHs—Mostly Original Substrate Humans. The drollery here is that *substrate*, for the last third of the 20th century, usually referred to silicon—the stuff that computer chips were built on. In Kurzweil's 2099, it means meat. A Mostly Original Substrate Human is one of those people who, for esthetic or ethical or moral reasons, insists on primarily using the flesh that humans were heir to for her living and thinking. MOSHs are honored and legally protected by "grandfather legislation," in Kurzweil's projection. They deserve it for being the progenitors of what humankind has become. But they cannot compete with those who have gone over to the other side. For those like Molly, it happened one incremental step at a time, as they chose to move on. Shedding the physical body was like shedding a large house that was a nuisance to maintain and no longer matched people's lives. It simplified things.

Work is still the point of human life in 2099. But those on the other side can do things of which MOSHs never dreamed. Molly is creating symphonies with frequencies, tempos and musical structures that MOSHs are not capable of understanding. All humans are now entrepreneurs, creating new knowledge, for which other people are willing to pay. A lot of time is filled by family, of which there are now many generations. To get to a point of peace and serenity, Molly meditates. She lives for moments of spiritual experience—"an artful expression, a moment of serenity, a sense of friendship."

Back in the early 21st century, in his office near Wellesley, I ask Kurzweil how he originally got into this prediction business. "Fairly conservatively," he replies. "I realized I needed to do some better modeling of technology trends to be a better inventor and entrepreneur. The world really was different by the time I finished a project. Early conceptions didn't necessarily pan out. Either they were too fast or too slow. I really needed to understand where technology would be—what the enabling forces would be. That's part of the craft of being an inventor. So that's how I got into this. Then it did take on a life of its own. This is what comes out of a scientific examination of technology trends. You come up with these perspectives and try to examine what that means for human civilization. It does create a philosophy. I try to actually overcome some of the older ways of thinking that are more death-oriented.

But I came to it through the scientific route. I wasn't trying to reverse-engineer a religious vision."

THE ESSENCE OF The Heaven Scenario is stealing fire from the gods, breathing life into inert matter and gaining immortality. Our efforts to become something more than human have a long and distinguished genealogy. Tracing the history of those efforts illuminates human nature. In every civilization, in every era, we have given the gods no peace.

Efforts to transcend our origins begin in the most primitive of times. Sorcerers would create a likeness of a living thing and, with the rituals of magic, seek to animate it. In our earliest epic, the Sumerian tale of Gilgamesh, the climax is the king seeking, finding and losing the secret of immortality. Barely three pages into Genesis, the serpent is telling Eve that she doesn't have to worry about losing immortality by tasting of the fruit of knowledge. "No! You will not die! God knows in fact that on the day you eat it your eyes will be open and you will be like gods," he says. (Not coincidentally, one of the biggest attractions of Christianity, even as an upstart religion, was its promise of eternal life.) Ancient Greece was full of heroes harassing the deities. Prometheus not only created humans, teaching them many of their useful skills, but he filched fire for them. Daedalus confounded King Minos by crafting wings of wax and feathers to flee Crete. His son Icarus, of course, flew too close to the sun, giving us one of our earliest warnings against taking presumptuous pride in our technologies. But remember, Daedalus did succeed—his mythic wings worked, and ancient Greece gave us the tools of logic, skepticism and natural philosophy that became the underpinnings of science. The market for harvest and fertility goddesses has never been the same.

The cultural humanism of the Renaissance pushed ancient pieties aside. *Make something of yourself!* was its message to mankind. Human nature was not predetermined by anybody's secondhand image and likeness, in this view. We could shape ourselves to make the world better. Pico della Mirandola's 1486 *Oration on the Dignity of Man*, the manifesto of the Italian Renaissance, eloquently centers all attention on human capabilities. In it, says God to Adam: "We give you no fixed place to live, no form that is peculiar to you, nor any function that is yours alone. According to your desires and judgment, you will have and possess whatever place to live, whatever form, and whatever functions you yourself choose."

Indeed, in 1580, the kabbalistic Jews of Prague imagined creating a Golem—an artificial man made from clay—who would protect them from persecution. Galileo, as he laid the foundations of modern science, believed that for peering directly into the mind of God, there was nothing like a telescope. It was more profitable to study the deity's handiwork than it was to study scripture. "Philosophy," he wrote, "is written in this grand book, the universe, which stands continually open to our gaze."

The Age of Enlightenment elevated scientists over priests. The notion was that the logically deduced laws that governed human behavior were an even purer expression of God's law than that which could be gathered from scripture. Since God's law will always work to good ends, the same must be true of the natural laws governing our individual lives, this hypothesis concluded. Francis Bacon was among the first to see critical reasoning as a means of finding the destiny and nature of man. "The formation of ideas and axioms by true induction is no doubt the proper remedy to be applied for the keeping off and clearing away of idols," Bacon wrote in *Novum Organum* in 1620. He saw it as a new grounding for morality and, indeed, the perfection of society. The idea of a rationally discovered natural law to achieve a heaven on earth would fuel both the American and French revolutions. Is the universe like clockwork? Then we, too, could be universal clockmakers. One of the wonders of the Paris salons of the 1730s was a complex mechanical duck created by the ingenious engineer Jacques de Vaucanson. It was able convincingly to waddle, eat fish and poop. It was the incarnation of René Descartes' idea of nature as machine. It was all the rage.

"Unlimited progress" was the future seen by Marie-Jean-Antoine-Nicolas de Caritat, Marquis de Condorcet, in his *Sketch for a Historical Picture of the Progress of the Human Mind*. A world in which "death would result only from extraordinary accidents" was foreseen by Condorcet, who was a friend of Voltaire. "No doubt man will not become immortal, but cannot the span constantly increase between the moment he begins to live and the time when naturally, without illness or accident, he finds life a burden?" This was published in 1795.

In 1780, Benjamin Franklin wrote to the chemist, biologist and minister Joseph Priestley, "The rapid progress true science now makes, occasions my regretting sometimes that I was born too soon. It is impossible to imagine the height to which may be carried, in a thousand years, the power of man over matter. We may, perhaps, deprive large masses of their gravity, and give them absolute levity, for the sake of easy transport. Agriculture may diminish its labor and double its produce: all disease may by

sure means be prevented or cured (not excepting even that of old age), and our lives lengthened at pleasure, even beyond the antediluvian standard. Oh that moral science were in as fair a way of improvement, that men would cease to be wolves to one another, and that human beings would at length learn what they now improperly call humanity."

If wresting power from the gods and seeking to transcend the human condition is fundamental to who we are, being terrified by the implications of our audacity is equally primal. Are we alarmed by the prospect of computers becoming human? Could that come from guilt? From fear? What happens if we create a monster? Will our silicon successes punish us? That is the horror and the dread. Call it "The Frankenstein Principle." The history of that idea begins in the summer of 1816, when Mary Wollstonecraft Shelley, while still a teenager, came to her spectacular leap of imagination. More about guilt, fear, horror and dread in the next chapter, on The Hell Scenario.

To continue tracing the history of stealing fire from the gods, however, in 1859, Charles Robert Darwin published *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life.* It changed everything. By placing humans in a history of millions of years in which all living things are connected and nothing is constant, it transformed the way people thought about God and themselves. Human nature is not etched in stone. This insight became the dominant metaphor of our age. The still-controversial *Origin of Species*—described by the philosopher Daniel Dennett as the greatest idea ever to occur to a human mind—became the most lastingly influential book of the modern era, surpassing even Freud and Marx.

A golden age of fiction about the future followed, much of it starting out quite utopian. With his series about extraordinary voyages, the Frenchman Jules Verne caught the enterprising spirit of the age, along with its uncritical fascination with inventions and scientific progress. *A Journey to the Center of the Earth,* in 1864, and *From the Earth to the Moon,* in 1865, rode the sense of optimism and godlike vistas humankind saw opening up for itself. The universe was our dominion, the environment ours to be mastered, from the planet's core to its orbit. In *Twenty Thousand Leagues Under the Sea,* Verne introduced one of the world's first superheroes, Captain Nemo, with his baroque, extravagant submarine, the *Nautilus.* That story so captured the sense of adventure and limitless possibilities of the age that Disney made it into a movie starring Kirk Douglas in 1954. The same year the United States Navy christened the first

nuclear submarine the *Nautilus.* In 1958 that vessel performed the mind-boggling, top-secret, hitherto considered impossible feat of sailing to the North Pole. (The Soviets were not amused.) Verne's *Around the World in Eighty Days* was made into a film in 1956 starring the aggressively international cast of David Niven, Cantinflas, Charles Boyer and Jose Greco.

A few decades after Verne, the Englishman Herbert George "H. G." Wells, in his more than 100 books, produced even more shocking, overwhelming divinations. His 1895 *The Time Machine* anticipated Einstein's theories in postulating time as the fourth dimension. Even eerier to a 21st-century reader is his 1896 *The Island of Dr. Moreau,* in which a mad scientist uses bioengineering to transform animals into human creatures. In movie versions, Dr. Moreau inspired such diverse actors as Charles Laughton, Burt Lancaster and Marlon Brando. Wells' *The Invisible Man* in 1897 was a Faustian story of a scientist who tampered with human nature in pursuit of transcendent, superhuman powers. *The War of the Worlds,* published in 1898, was so powerful a tale of Martians invading the earth that when Orson Welles' news-bulletin-style Mercury Theater radio dramatization was broadcast on October 30, 1938, widespread panic ensued.

H. G. Wells' prescience was extraordinary. In *The World Set Free* he wrote, "Nothing could have been more obvious to the people of the early twentieth century than the rapidity with which war was becoming impossible. And as certainly they did not see it. They did not see it until the atomic bombs burst in their fumbling hands." He wrote that in 1914. In 1920, he described human history as becoming "more and more a race between education and catastrophe."

By the middle of the 20th century, after the Industrial Revolution had delivered one miracle after another—electricity, the telephone, radio, the airplane—a remarkable change occurred in our culture and values. People no longer found startling the idea that man had acquired godlike powers to reshape himself and his environment. (The first Superman comic book appeared in 1938.) They did, however, begin to anticipate The Hell Scenario. They questioned whether technological change really equaled "progress."

Meanwhile, in the late 20th century, fiction continued to be the key forum pushing the boundaries of our imagination about what could happen to the future of human nature. Novels stretched our conceptions of human-created Heaven, kick-starting our thinking about what was possible, forcing us to change our perception of what was serious. Arthur C.

Clarke's *2001: A Space Odyssey*—vividly brought to the screen in 1968 by Stanley Kubrick—introduced us to HAL, the intelligent computer. The biochemist Isaac Asimov shaped an entire generation of roboticists with his stories, starting with *I, Robot*. What would machines that had ethics behave like? He imagined what he called the Three Laws of Robotics: "The First Law—A robot may not injure a human being or, through inaction, allow a human being to come to harm. The Second Law—A robot must obey orders given it by human beings except where such orders would conflict with the First Law. The Third Law—A robot must protect its own existence as long as such protection does not conflict with the First or Second Law." Later, in his Foundation series, Asimov explored the notion that the social sciences and history had fundamental laws as immutable and calculable as those of mathematics or physics and that these truths, properly understood, could help perfect society. These stories molded the scenario-planning industry.

Popular culture continued the quest to imagine transcendence. Michael Crichton's 1972 novel, *Terminal Man*, became the television series *The Bionic Man*. The hottest writer in Hollywood in the early 21st century, Philip K. Dick, had been dead for two decades. The scruffy, poverty-stricken, five-times-married, clinically paranoid Dick, a garage philosopher, autodidact and conjurer of false realities, never cared much about robots or space travel. He was, however, fascinated by hallucinatory worlds in which there is a blur between what is real and what is not. Needless to say, that has become a very hot subject as we try to process living in a time that includes telekinetic monkeys. Dick's work has become the stuff of big budgets, exalted directors and illustrious actors, such as Ridley Scott's *Blade Runner*, starring Harrison Ford; Paul Verhoeven's *Total Recall*, with Arnold Schwarzenegger; Steven Spielberg's *Minority Report*, starring Tom Cruise; and John Woo's *Paycheck*, with Ben Affleck and Uma Thurman. Dick's sensibility is all over *The Matrix*.

The impact of such storytelling on global culture should not be underestimated. In my travels I found it hard to find a cutting-edge researcher today who, when asked about the inspiration for his creations, did not reply by simply pointing to a shelf in a place of honor. There invariably sat expensively collected fables of the future that shaped his youth. For Kurzweil, it was the Tom Swift Jr. series.

"My personal philosophy," Kurzweil says, "is there is no problem or challenge that comes along that there isn't an idea to overcome that problem. I first encountered this idea in the Tom Swift series, which I have over there. Actually, those books on the left is the Tom Swift Sr. series. Those are original books, almost 100 years old." The ones on the right were the books from the Tom Swift Jr. series of 1954 to 1971 that Kurzweil devoured when young, such as the 1956 *Tom Swift in the Caves of Nuclear Fire*.

"I've been collecting them. I had the whole series, but I've been recollecting them. If you remember how those books all progressed, Tom Swift Jr. would get into some jam, along with his friends and usually the whole human race. He would kind of go into his lair. That's what kept you reading—how is he going to get out of this jam? But it was always an idea, some clever insight. Really, the moral of each of these books was the power of the idea. There is no problem that you can get into where some well-leveraged idea wouldn't save the day."

Thence come our ideas of transcending origins and becoming something more than we are. Thence comes our demonstration that stealing fire from the gods is at the heart both of human nature and of The Heaven Scenario.

To expect the unexpected shows a thoroughly modern intellect.

—Oscar Wilde

"Why make people inquisitive, and then put some forbidden fruit where they can see it with a big neon finger flashing on and off saying 'THIS IS IT!'?," says the angel Aziraphale.

"I don't remember any neon," replies the demon Crowley.

"Metaphorically, I mean. I mean, why do that if you really don't want *them to eat it, eh? I mean, maybe you just want to see how it all turns out. Maybe it's all part of a great big ineffable plan. All of it. You, me, him, everything. Some great big test to see if what you've built all works properly, eh? You start thinking: it* can't *be a great cosmic game of chess, it* has *to be just very complicated Solitaire."*

—Neil Gaiman and Terry Pratchett, *Good Omens*

Scene: Alan Turing in the Bell Labs cafeteria, 1943

His high pitched voice already stood out above the general murmur of well-behaved junior executives grooming themselves for promotion within the Bell corporation. Then he was suddenly heard to say: "No,

I'm not interested in developing a powerful brain. All I'm after is just a mediocre brain, something like the President of the American Telephone and Telegraph Company."

—Andrew Hodges, *Alan Turing: The Enigma of Intelligence*

WASHINGTON IS A tribal town. One of its rituals involves code words. These evoke vast and nuanced concepts to those in the know, while sometimes appearing meaningless to outsiders. One of these words is *serious*, as in "He is a serious person," or not, or "That is a serious idea," or not. *Serious* does not necessarily have anything to do with whether the person or idea is correct, important or valuable, no matter what insiders would have you believe. *Serious* means that the notion or individual has been cleaned up, molded and adopted by sponsors already vetted as serious. It implies that the idea or person is deemed ready for admittance to the sacraments of authority—such as congressional hearings—which can lead to that Holy Grail, federal funding. It suggests a certain WASP respectability. It basically means housebroken.

That is why it is interesting to watch The Heaven Scenario begin to be taken seriously in parts of Washington. Two very serious organizations are the National Science Foundation and the United States Department of Commerce. They became regarded as serious in part because of their sober reputation for not taking injudicious chances. They also have wildly separate constituencies. Thus it is pretty remarkable to see them team up to produce a Washington policy document saying, "It is time to rekindle the spirit of the Renaissance" to achieve "a golden age that will be a turning point for human productivity and quality of life."

The 415-page, three-pound pronouncement entitled *Converging Technologies for Improving Human Performance* comes complete with PowerPoint-ready bullet points laying out the radical evolution of humans for those with the attention span of a Cabinet secretary. Note how many exceed even some of Kurzweil's more startling predictions. Note also, because it is a Washington policy document, how quickly it cuts to the chase, aiming at constituencies in defense, in industry and in management of the economy, while genuflecting in the direction of many potentially important adversaries.

The bullet points in part say that in the next 10 to 20 years the advantages of radical evolution will include the following:

- Direct connections between the human brain and machines "will transform work in factories, control automobiles, ensure military superiority, and enable new sports, art forms and modes of interaction between people."
- Wearable sensors will "enhance every person's awareness of his or her health condition, environment, chemical pollutants, potential hazards, and information of interest about local businesses, natural resources, and the like."
- Teams will be able to "cooperate profitably across traditional barriers of culture, language, distance, and professional specialization."
- "The human body will be more durable, healthy, energetic, easier to repair, and resistant to many kinds of stress, biological threats, and aging processes."
- "Machines and structures of all kinds, from homes to aircraft, will be constructed of materials that have exactly the desired properties, including the ability to adapt to changing situations, high energy efficiency, and environmental friendliness."

  Technologies will "compensate for many physical and mental disabilities and will eradicate altogether some handicaps that have plagued the lives of millions of people."

  "National security will be greatly strengthened by lightweight, information-rich war fighting systems, capable uninhabited combat vehicles, adaptable smart materials, invulnerable data networks, superior intelligence-gathering systems, and effective measures against biological, chemical, radiological and nuclear attacks."
- "Anywhere in the world, an individual will have instantaneous access to needed information."
- "Engineers, artists, architects, and designers will experience tremendously expanded creative abilities," in part through "improved understanding of the wellsprings of human creativity."
- "The vast promise of outer space will finally be realized by means of efficient launch vehicles, robotic construction of extraterrestrial bases, and profitable exploitation of the resources of the Moon, Mars, or near-Earth asteroids."
- "Average persons, as well as policymakers, will have a vastly improved awareness of the cognitive, social, and biological forces

operating their lives, enabling far better adjustment, creativity, and daily decision making."

"Factories of tomorrow will be organized" around "increased human-machine capabilities."

"Agriculture and the food industry will greatly increase yields and reduce spoilage through networks of cheap, smart sensors that constantly monitor the condition and needs of plants, animals, and farm products."

"Transportation will be safe, cheap, and fast."

"Formal education will be transformed" by an understanding of "the physical world from the nanoscale through the cosmic scale."

It concludes: "The twenty-first century could end in world peace, universal prosperity, and evolution to a higher level of compassion and accomplishment." It may be "that humanity would become like a single, distributed and interconnected 'brain.'"

Mihail C. Roco and William Sims Bainbridge of the National Science Foundation are the co-authors of this document. Roco is a compact man who speaks English with a thick accent that even some of his colleagues assume is Russian. This turns out to be a very big mistake. He was born in Bucharest, Romania, and is incensed and incredulous that anyone might be ignorant enough to make an error about this.

Roco is senior adviser for nanotechnology at the National Science Foundation, chair of the National Science, Engineering and Technology Council's subcommittee on nanoscale science, engineering and technology, chair of the President's National Science and Technology Council's Interagency Nanoscience, Engineering and Technology working group, and chair of the National Science and Technology Council's subcommittee on nanoscale science, engineering and technology. He is credited with 13 inventions.

Roco's version of The Heaven Scenario is driven by much more than The Curve. He sees transcendence resulting from no less than the convergence of all human wisdom. "The hallmark of the Renaissance was its holistic quality," he and Bainbridge write, "as all fields of art, engineering, science and culture shared the same exciting spirit and many of the same intellectual principles. A creative individual, schooled in multiple arts, might be a painter one day, an engineer the next, and a writer the day after that. However, as the centuries passed, the holism of the Renaissance gave way to specialization and intellectual fragmentation." Today, that's over, he says. "It's time to rekindle the spirit of the Renaissance."

The GRIN technologies—genetics, robotics, information technology and nanotechnology—drive a unified theory of everything, in this view. The information technology is the sire of them all. Here's how they intertwine.

One of the most challenging thinkers about the future of human genetics, the G in the GRIN technologies, is Gregory Stock. He is director of the Program on Medicine, Technology, and Society at the School of Medicine of the University of California at Los Angeles.

Stock's version of The Heaven Scenario departs from Kurzweil's. He doesn't think humans will transcend because of computers. He thinks humans will transcend because of genetic engineering. Such biological remodeling is "a plausible way for people to overcome their bodily frailties, but a larger game is afoot," he says. It is "biology's bid to keep pace with the rapid evolution of computer technology."

"No one really has the guts to say it, but if we could make better human beings by knowing how to add genes, why shouldn't we?" he approvingly quotes James Watson, co-winner of the Nobel prize for discovering the structure of DNA, as saying. The titles of several of Stock's books display his position. One is called *Redesigning Humans: Our Inevitable Genetic Future*. An earlier one is called *Metaman: The Merging of Humans and Machines into a Global Superorganism*.

"To not be human in the sense we use the term now" is the fate of our descendants, Stock says. We will soon see humans as physically and intellectually divergent as "poodles and Great Danes." But the passing of people like us is hardly a tragedy, he believes. "Unlike the saber-toothed tiger and other large mammals that left no descendants when our ancestors drove them to extinction, *Homo sapiens* would spawn its own successors by fast-forwarding its evolution."

That's not far off, says Stock. It's a whole lot closer than the "distant space travel we see in science fiction movies." He sees it as the inevitable outcome of the decoding of the human genome. "We have spent billions to unravel our biology, not out of idle curiosity, but in the hope of bettering our lives. We are not about to turn away from this." Genetic transcendence "does not hinge on some cadre of demonic researchers hidden away in a lab in Argentina trying to pick up where Hitler left off. The coming possibilities will be the inadvertent spin-off of mainstream research that virtually everyone supports. Infertility, for example, is a source

of deep pain for millions of couples. Researchers and clinicians working on in vitro fertilization (IVF) don't think much about future human evolution but nonetheless are building a foundation of expertise" that will "one day be the basis for the manipulation of the human species," he says matter-of-factly.

There are two kinds of genetic engineering. The first is called somatic gene therapy. The phrase comes from the Greek word *soma*, meaning "body." It's intended to fix genes gone bad in one person. It treats wrenchingly awful diseases such as cystic fibrosis, immune deficiency disorders, sickle-cell anemia and hemophilia. Somatic gene therapy usually is not terribly controversial—except when it kills the person on which it is being tested, and especially when that person was not adequately informed of the risk, as happened in the 1999 death of Jesse Gelsinger. The reason somatic therapy is not hugely debated is that it only swaps out bad genes in specific areas—the lungs, the liver—of the person being treated. Changes are not passed on to succeeding generations. Thus it is usually viewed as not tremendously different from surgery. Even the Amish use it.

Where the balloon goes up is over germ-line interventions. *Germ* comes from the Latin word for "root." Germ-line engineering changes the genetic makeup of the embryo at the very start, altering the child's every cell. Thereafter, it changes every grandchild and great-grandchild propagated, forever. This is where the controversy over "designer babies" begins. It is the vision in which people start by selecting the color of their kid's eyes, and the next thing you know, you have "clusters of genetically enhanced superhumans who will dominate if not enslave us," as Stock puts it. Yet he dismisses such horror stories. "No one understood the powerful effects of the automobile or television at its inception," he notes. "Our blindness about the consequences of new reproductive technologies is nothing new, and we will not be able to erase the uncertainty by convening an august panel to think through the issues. No shortcut is possible. As always, we will have to earn our knowledge by using the technology and learning from the problems that arise."

If it's safe, it ain't sex. But risks in reproduction, we're wary about. That's why Stock is betting that we'll like artificial chromosomes. Right now, we have 23 chromosome pairs, with the chromosomes numbered 1 through 46. Messing with them is tricky—you never know when you're going to inadvertently step on unanticipated interactions. If, however, we add a new chromosome pair (numbers 47 and 48) to the embryo, the possibilities are endless. Think of it as scaffolding. It doesn't change anything itself. It just holds plug-in points where you can stick gene modules and their controls. "The auxiliary chromosome would be a universal delivery vehicle for gene modules fashioned by medical geneticists throughout the world," Stock says. He sees it as the safest way to substantially modify humans. It would minimize unintended consequences. On top of that, the insertion sites could have an off switch activated by an injection if we wanted to stop whatever we'd started. This would give future generations a chance to undo whatever we did, if they choose. It would also allow us to stick modifications into our kids that they could choose to turn on or off later in life, as they become adults. "When children who have received auxiliary chromosomes to improve some mental or physical characteristic grow up, they may want to give their own child the same advantage. They won't, however, want to pass on the outdated auxiliary chromosomes they received a generation earlier, any more than a middle-aged father today would try to give his Internet-savvy college-bound daughter that state-of-the-art typewriter he used for his term papers," Stock says. "Parents will want the most up-to-date genetic modifications available. Were these prospective parents' own modifications scattered through their chromosomes, cleaning them out and upgrading them would be tricky, but with changes confined to an auxiliary chromosome, a parent could simply discard the entire thing and give his or her child a newer version." He sees this as disarming the ethical argument, offered by the Council for Responsible Genetics, that germ-line engineering should be unconditionally banned because future generations screwed up by wrongful or unsuccessful germ-line modifications would have no control over the matter.

What would the impact of all this be? Genetic research is one of the ways the NSF report sees us quickly getting to "vastly improved awareness of the cognition, social, and biological forces" operating our lives. James Watson, the provocative co-discoverer of the structure of DNA, talks about molecular biology curing stupidity. "If you are really stupid, I would call that a disease," the Nobel laureate says. He also has few qualms about engineering beauty: "People say it would be terrible if we made all girls pretty. I think it would be great."

Stock—who with his deep-set, penetrating eyes, carefully barbered beard and youthfully bushy head of gunmetal-gray hair could moonlight as a local TV anchor—personally prefers the idea of becoming genetically altered flesh, rather than Kurzweil's kind of beyond-human machine. But

he also sees his own Heaven Scenario as "tame" and near-term compared to Kurzweil's. Rudimentary artificial chromosomes already exist. Within a few years "we should have a fair idea of the size of the task facing future genetic engineers," he says. By then, "traditional reproduction may begin to seem antiquated, if not downright irresponsible." He sees his projections as not at all out of touch with reality, compared to Kurzweil's, which he characterizes as "far-fetched," "techno-exuberance" and a "huge leap of faith."

Perhaps that is another useful definition of human nature—the species that punctuates the most far-reaching discussions of its future with asides about how competitors stink.

Nanotechnology, the *N* in the GRIN technologies, means manipulating the unimaginably small. A nanometer is one billionth of a meter. It is the length of five carbon atoms in a row or the distance your fingernail grows in one second. If a nanometer were the size of your nose, a red blood cell would be the size of the Empire State Building, a human hair would be more than two miles thick, your finger would span the United States from the Atlantic to the Pacific, and a person would be taller than six planet Earths stacked one on top of the other. Just as there are two kinds of genetic engineering, there are two kinds of nanotechnology, one more far-reaching and controversial than the other. The first kind is the one already coming into existence. It reduces big things to sizes so astonishingly little that their behavior changes dramatically—transistors, for example, or the active ingredients in sunblock. By 2003, hundreds of tons of nanomaterials were being made in U.S. labs and factories. Such nanotechnology is expected to be a $1 trillion business by 2015—comparable to the gross national product of Canada.

The other kind of nanotechnology is the one its proponents say promises godlike powers, immortality and unimaginable wealth. Its detractors say it will doom us and every living thing on the planet. This form of nanotechnology is intended to work the other way around from the first. It involves taking individual atoms and stacking them into any large thing we want, from diamonds to spacecraft.

The person credited with inspiring nanotechnology is the late Richard Phillips Feynman. He became widely known as an American original for his wildly best-selling 1985 autobiography *Surely You're Joking, Mr. Feynman!* in which he discusses, in his relentless pursuit of knowledge, gambling with Nick the Greek, painting a naked female toreador, and accompanying a ballet on his bongos. Before that, Feynman was merely

the renowned Caltech physicist who won the Nobel Prize for his work on quantum electrodynamics.

On December 29, 1959, at a meeting of the American Physical Society, Feynman gave an after-dinner talk entitled "There's Plenty of Room at the Bottom." At a time when the audience freshly remembered computers that used vacuum tubes the size of candy bars, he talked about storing "all the information that man has carefully accumulated in all the books in the world" in a cube "one two-hundredth of an inch wide—which is the barest piece of dust that can be made out by the human eye. So there is *plenty* of room at the bottom!"

In his lecture, Feynman described a world in which you "give the orders and the physicist synthesizes it. How? Put the atoms down where the chemist says, and so you make the substance." Make computers much smaller and therefore faster, he said. Make "mechanical surgeons"—nanobots—that could travel to trouble spots inside the body. To get things going he offered two prizes: $1,000 to the first person to make a working electric motor no bigger than 1/64 of an inch in any dimension, and another $1,000 to the first person to shrink text such that the entire *Encyclopaedia Britannica* would fit on the head of a pin. The prize for the motor was awarded almost immediately, in 1960. The text prize was awarded in 1985.

Much of nanotechnology at the beginning of the 21st century involved zapping relatively large amounts of things until they become small enough to acquire unusual powers. For example, the marvelously surnamed Richard E. Smalley of Rice University shared the 1996 Nobel prize for chemistry for hitting a batch of pure carbon with a special laser beam until the atoms rearranged themselves into a previously unknown molecule—a ball made of 60 atoms that looked like the kind of geodesic domes pioneered by Buckminster Fuller. The molecule is nicknamed the "buckyball" in Fuller's honor. Buckyballs and their cousins, the nanotube fibers, have many intriguing properties, including 60 times the strength of steel, the weight of plastic, the electrical conductivity of silicon, the heat conductivity of diamond and the size and perfection of DNA.

The U.S. government is throwing big bucks at jump-starting this sort of nanotechnology, because, among other things, it sees national security implications. Boeing is working on cutting the weight of rockets, aircraft and satellites. Asian and European governments are also frantically attempting to achieve a lead in what is hyped as overwhelmingly The Next Big Thing. General Electric, Motorola, DuPont, Lucent and Kodak are

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pursuing nanotech. The first nano products trickling to market were not terribly impressive—self-cleaning windows and non-staining trousers. It is the promise, however, that drove Congress wild. What might you do with nanotechnology? Defeat biological warfare. Defeat all disease, in fact. Nano may be the basis of half of all pharmaceuticals by 2010. Heal the environment—lock up carbon dioxide in the atmosphere, consume toxic waste. End our dependence on oil—produce solar panels embedded with nanocrystals so efficient and flexible that they can be used in everything from roof shingles to clothing. Conquer space. The U.S. National Aeronautics and Space Administration loves what you could do with enough carbon nanotubes—the strongest, lightest material ever made. You could stretch a cable 22,347 miles to a stable point in space. You could then run electromechanical vehicles along it full of people and payloads. What you'd have is a space elevator. Five-hour ride, one-way. Forget those preposterously expensive chemical rockets that haven't changed much since the 1960s. Forget those painfully fragile landing craft so susceptible to burning up on reentry. This could be the breakthrough to the stars, NASA says.

Mind you, that's the mild version of nanotechnology. That's not where you get the real excitement. The real excitement explodes from the second kind of nanotech. It starts with the work of K. (for Kim) Eric Drexler. In the 1970s, as an MIT undergraduate, Drexler noted that all life in every jot of its riotous variety is created by little biological machines like those in photosynthesis that manipulate basic elements of matter. Why not adapt those methods to build nonliving things? he wondered. Why not build computer-driven machines with parts the size of molecules to haul atoms to precisely the correct locations to build anything you pleased? *Anything you pleased.* In 1986, he single-handedly launched and named the nanotech industry with his book *Engines of Creation: The Coming Era of Nanotechnology,* which explained how his ideas could truly change the world. With nanotechnology, you could grow a house, or a car, or a completely real, molecularly accurate T-bone steak, or a new heart, from little more than software instructions and some handfuls of dust. It would enable digital control of the very structure of matter.

Even as he approaches 50, Drexler maintains an uncanny ability to look like a graduate student. He's as gaunt as a stray puppy. You want to take him home and feed him. Sitting in Silicon Valley's Original House of Pancakes in Los Altos, his breakfast order seems promising—a robust

plateful of ham and eggs. Then he lets them get cold as he quietly but intensely explains the vast implications of the world he sees us entering.

If anything, Drexler is even more optimistic than Stock and Kurzweil. He wears a medallion around his neck that asks the finder, in case of Drexler's death, to "Call now for instructions/Push 50,000 U heparin by IV and do CPR while cooling with ice to 10C/Keep PH 7.5/No embalming/No autopsy." He and others believe that robots smaller than a red corpuscle will soon work like Pac-Man, gobbling up diseased cells and keeping the human body perpetually in tune. If he were to meet an untimely end before that day arrives, however, Drexler plans on coming back from the dead. That's why he's wearing the medallion. He wants to get frozen right next to Ted Williams so that when the appropriate technology arrives, he can be thawed, have a nanotech workover and a slap on the butt and get on with his efforts.

Does he think this will make him immortal?

"Depends on what you mean by immortal," he says, still ignoring his eggs. "There is such a thing as proton decay."

Pause.

He's talking about the eventual collapse of subatomic particles in eons vastly beyond the time it will take for the solar system to die.

Okay, what about merely geological time? Hundreds of thousands of years?

"Oh yeah." He smiles. "That. For sure."

One problem with a genie like strong nanotech is what it might demand in return for granting your every wish. Drexler now calls his original vision of nanotech "molecular manufacturing" to distinguish it from what he views as the promiscuous debasement of the word *nanotech* to include anything small, including ordinary chemistry. The key idea about his vision of nanotech is the creation of "assemblers." Assemblers would be the molecular manufacturing machines that would seek out the appropriate atoms and put them in the right places. Of course, since it would take billions of assemblers to make a product of any significant size, the first thing an assembler would have to do is make a second assembler. Then each would make another one, and so on, up the exponential curve, doubling and redoubling their numbers. There are several pause-giving aspects to this. One is that nobody knows how to make an assembler—they are hypothetical. (In fact, those seeking venture capital for their near-term visions of nanotechnology dismiss Drexler as at best a daydreamer and at worst a "scarer of children.") A second is

that were the "assembler breakthrough" ever to start, it's hard to know how to steer. The world might be transformed so utterly and abruptly by such a breakthrough as to resemble The Singularity. Another problem is that even if you got them started and steered, you'd better be awfully sure you know how to make them stop. If they can't be made to stop, in principle they could blithely reproduce themselves until they've consumed every bit of energy on the planet, wiping out all life. This is the "gray goo" plot that is a critical element of The Hell Scenario.

Nonetheless, the promise is staggering. Nanotech is where the NSF gets the idea that the human body will soon start conquering age, the energy crisis will be solved, the environment will be cleaned, aircraft will be more adaptable than birds, and the American armed forces will be invulnerable.

As in genetic engineering and nanotechnology, computer intelligence, the *I* in GRIN, has two meanings. There is strong artificial intelligence and weak machine intelligence. *Weak* essentially means that it does a pretty good job of imitating humans. *Strong* means that it *is* intelligent in important ways. It *is* conscious. It *is* a challenge to the identity of humans and their human nature. Weak machine intelligence is the United Airlines reservation computer that hears what you're saying on the phone when you ask whether your plane will be on time, and responds to you usefully in a mechanical voice. Strong artificial intelligence, if it ever comes to be, is you not being able to tell whether or not you're talking with another flesh-and-blood person. Weak machine intelligence can and does fly a jumbo jet 10,000 miles across the Pacific, setting it down in Hong Kong with such soft precision—and without the pilot touching the controls—that the passengers applaud the landing. Attempts at strong artificial intelligence cannot yet achieve the common sense we expect of a three-year-old when she dresses herself.

Marvin Minsky is the grand old man of the notion that a successful computer model of the brain will be able to explain how it thinks. Young researchers now regard as quaint some of his views that consciousness can be described as machinelike. Nonetheless, Minsky is revered. In 1959 he co-founded what would become the MIT Artificial Intelligence Lab. (In fact, he was present when the term *artificial intelligence* was invented in 1960.) He is one of the last living links to the early pioneers of the Information Age, under some of whom he studied. His work on artificial intelligence is still regarded as the pushing-off point for discussions of machine intelligence. His students fill the field. He remains as inquisitive as a squirrel with a new bird feeder.

It's a treat to see Minsky perform. This winner of the Japan Prize—that nation's highest honor in science and technology—thinks nothing of showing up at august academic forums in a palm-tree-decorated Hawaiian shirt. His very bald head is now marked by light liver spots and a wild fringe of long baby-fine white hair near his neck. His smile is as wide as a frog's. He is a great waver of his arms over his head as he makes pronouncements like "There is nothing certain but taxes"—conspicuously excluding death. He sports a credit-card-sized digital camera on a silver cord around his neck, black leather sneakers with Velcro fasteners on his feet, and a telescope in his pocket with which he recognizes people blocks away. He wears a belt woven of 8,000-pound-test Kevlar filament that can be quickly unraveled into a single cord with which you can pull your car out of a ravine. On this belt hangs a pouch full of tools, including lasers and cutting implements. Seems reasonable to him. "Who would fix the plane if it got into trouble?" he asks.

Minsky believes it is important that we "understand how our minds are built, and how they support the modes of thought that we like to call emotions. Then we'll be better able to decide what we like about them, and what we don't—and bit by bit we'll rebuild ourselves. He views this project of understanding intelligence as comparable to "only two earlier inventions: those of language and of writing." He sees it as a matter of urgency. "The more we can learn about how human minds work, the better we will be able to guide the development of our genetic successors or of beings whose making we'll supervise," he says.

"Why should we alter ourselves instead of forever remaining the same? Because we have no alternative. If we stay unchanged in our present state, we are unlikely to last very long—on either cosmic or human scales of time. In the next hundred or thousand years, we are liable to destroy ourselves, yet we alone are responsible not only for our species' survival but for the continuation of intelligence on this planet, and quite possibly in this universe." He takes The Hell Scenario seriously. He recites a long list of ways that we can become extinct, from global warming to rogue asteroids. His solution? "We've seen many suggestions about dealing with these, but none of them yet seem practical. A more practical course might simply be," he says, to focus "instead on finding ways to make ourselves more intelligent."

As with strong nanotechnology, strong artificial intelligence has not yet been achieved. Nonetheless, advances in machine intelligence are what the NSF has in mind when it discusses direct connections between you and your car, factory work, environment and weapons, as well as the cre-

ation of new arts, sports and ways to transcend cultural and language barriers between people.

Robots, meanwhile, have come a long way from Karel Čapek's 1921 play *R.U.R.*, for "Rossum's Universal Robots," whence comes the word *robot*. The Japanese—especially Sony and Honda—love to create two-legged humanoid mechanical creatures. In the time-honored tradition of nearly life-sized Bunraku stage puppets, Honda has fielded a squad of Asimo robots, the company's walking, talking, child-sized pseudohumans. The company says its long-term aim is to create "a partner for people." Sony's "corporate ambassador," meanwhile, is a two-foot-tall humanoid called Qrio. Qrio is produced by Sony's Entertainment Robot Company, which already sells Sony's robot dog, Aibo. The company's president, Satoshi Amagai, says that Japanese Aibo owners have a more emotional relationship with their mechanical pets than do Americans or Europeans. The AIBO ERS-7, at $1,599, promises to have six emotions—happiness, anger, fear, sadness, surprise and discontent. Pat one on the head and it appears to become happy enough to do tricks. Whack it on the nose, and it not only appears hurt, it learns not to repeat certain behaviors while prompting that profound philosophical question: Is it wrong to kick a robotic dog?

In much of the rest of the world, meanwhile, robots—defined as digitally driven creatures that can sense and move—have taken on new forms of life. "We are trying to build robots that have properties of living systems that robots haven't had before," says Rodney Allen Brooks, chairman and chief technical officer of iRobot, the company that brought to market the Roomba—America's first cheap, practical, sweeping and vacuuming robot. It looks like a portable CD player the size of a toilet seat. By all accounts, it really does clean the floors. Even under the bed. More than half the owners of these robots give them names. Finally in Brooks we have a roboticist whose achievements we can take seriously.

Oh yes, Brooks has a few other credentials as well. He is director of the MIT Artificial Intelligence Laboratory, Fujitsu Professor of Computer Science at MIT, and author of *Flesh and Machines: How Robots Will Change Us*. (Did you say the name of his company, iRobot, reminded you of the title of the Isaac Asimov book mentioned above that influenced a whole generation of roboticists? Told you.)

Actually, the person who led the robot charge toward The Heaven Scenario was Hans Moravec of Carnegie Mellon University in Pittsburgh. In 1988 this pioneer published *Mind Children: The Future of Robot and Human Intelligence*. In its first few sentences, it painted a picture in

which humans were swept away. We "have produced a weapon so powerful it will vanquish the losers and winners alike," Moravec said. But even though the Cold War was still on, he didn't mean nuclear weapons. He meant the intelligent children of our minds, his beloved robots. By 2008, he thought, they would be able to perform like humans on the gear contained in a $10,000 personal computer. By 1998, in *Robot: Mere Machine to Transcendent Mind*, Moravec acknowledged that his time frame was a trifle ambitious. (At the same time, his computer-price projections turned out to be laughably conservative.) Nonetheless, he predicted the near arrival of general-purpose robots that could figure out where they were in a room with the precision of a lizard, followed by robots with the adaptability of a mouse, followed by robots with the imagination of a monkey, followed by those with human reasoning. His predictions carefully copied the biological evolutionary ladder up the scale as computers became more and more powerful. No more will that proud race called robot be sadly stuck welding Corolla fenders day after day. Moravec's vision is one in which robots can be autonomous, responding innovatively to complex and unanticipated situations. Real robots roam.

Indeed, by the 100th anniversary of the Wright brothers' 1903 flight, at least 32 countries were developing more than 250 models of flying robots, with 41 countries already operating them. (In the last week of the first Gulf War, five Iraqi soldiers waved white flags at a U.S. Pioneer unmanned air vehicle—the first time in history somebody tried to surrender to a robot.) Already in the air were reconnaissance robots the size of sparrows, such as the Black Widow. The next generation would be the size of insects. Such robots will find markets among firefighters, environmentalists, border patrols, film producers and farmers. The U.S. Department of Defense is expecting pilotless aircraft the size of F-16 jet fighters to suppress enemy air defenses and sensors by 2012. Cargo-lifting pilotless craft originally designed to supply soldiers were expected one day to replace FedEx vans. The story in aviation circles was widespread that in the future, passenger plane cockpits would only have a pilot and a dog. The pilot's job would be to watch the robot's computer screens. The dog would be there to bite the pilot if he tried to touch anything.

But Brooks goes much farther than that. "We're trying to build robots that can repair themselves, that can reproduce (although we're a long way from self-reproduction), that have metabolism, and that have to go out and seek energy to maintain themselves." Forget the image of a man in a can. "Our theme phrase is that we're going to build a robot out of Jello.

We don't really mean we're actually going to use Jello, but that's the image we have in our mind. We are trying to figure out how we could build a robot out of 'mushy' stuff"—like flesh—"and still have it be a robot that interacts in the world."

Is Brooks worried about this all going too far? Well, he admits that Bill Joy—who in the next chapter details his fears about technology overrunning mankind—has stimulated him. "I have several interesting robotics projects underway," he says. "One of the robots I must say was inspired by Bill Joy, probably to his dismay. We have a robot now that wanders around the corridors, finds electrical outlets and plugs itself in. The next step is to make it hide during the day and come out at night and plug itself in. I'd like to build a robot vermin," Brooks says. He loves the idea of building a robot that could be killed only by locking it in a room with no power outlets or by going after it with a hammer. "I'm trying to build some robots like that as thought-provoking pieces—and just because Bill Joy was afraid of them," he says. Just what the world needs—a roboticist with a sense of humor.

Brooks is also trying to build robots made out of Legos that can make copies of themselves out of more Legos. There is a deep mathematical question of whether this is possible, but basically he says that's what machine self-reproduction will look like. After all, he points out, biological molecules can do that. Meanwhile, his iRobot company is big into PackBots. These are emergency and military robots weighing some 50 pounds that can be carried by one person. They can be dropped from a reasonably low-hovering helicopter and do search and rescue, disarm bombs, or perform reconnaissance in caves into which humans don't want to stick their heads. (DARPA loves the experimental versions being pioneered at the University of California at Berkeley that want to climb straight up walls and hang from ceilings, like those gecko lizards with suction pads on their feet after which they are modeled. DARPA also gets dizzy at the thought of air-dropping entire networks of tiny "throwbots" that can work with each other to saturate a battlefield.) Making these bots impervious to the abuse and neglect of a 19-year-old American is a very big challenge. But the troops so far deem them worth humping—no small compliment.

Brooks is both enthusiastic and sanguine about The Heaven Scenario. "Fairly soon, we may have to start banning kids with neural Internet connection implants from having them switched on while taking the SATs," he says. Shortly after that, he thinks, such implants will be mandatory after the SATs are revised to accommodate such people. As a result, "we will become a merger between flesh and machines. We will have the best that machineness has to offer, but we will also have our bioheritage to augment whatever level of machine technology we have so far developed. So we (the robot-people) will be a step ahead of them (the pure robots). We won't have to worry about them taking over."

This merger of flesh and machine is what the NSF is thinking of when it talks about machines operating "on principles compatible with human goals, awareness, and personality." That's also what it's talking about when it contemplates "construction of extraterrestrial bases, and profitable exploitation of the resources of the Moon, Mars, or near-Earth asteroids."

Who knows if all these GRIN technologies collectively will produce "world peace, universal prosperity, and evolution to a higher level of compassion and accomplishment," as the National Science Foundation would have us believe. If a fraction of these technologies has non-negligible possibilities, however, even that will have an overwhelming impact on humanity.

HOW WOULD WE KNOW if we were achieving The Heaven Scenario? I ask Kurzweil. How would we know if we were transcending human nature? What would the milestones be?

"Well, it depends on how you define human nature," he replies.

Kurzweil defines humans as "that species that seeks to extend its own horizons—that represents the cutting edge of evolution." It embodies "evolution towards ever greater knowledge and intelligence and creativity." If you buy that definition, he holds, "then there is no transcending it. It is, ultimately, the cutting edge of transcendence."

If, however, you "define it in more limited ways, such as human beings are a certain biological species that has brains organized in this certain biochemical way, then we will transcend that. Since the technology is going to grow exponentially, ultimately the non-biological portion will dominate."

One nice thing about our becoming less biological, he says, is that we'll be easier to upgrade. The way we do things now is a nuisance. For example, for most of human and prehuman history, every last calorie was precious—you never knew when famine would hit, so it was better to hold on to all those calories while you could, as the extra fat might be crucial to your survival.

"But now we live in a completely different period—at least I do—in a period of abundance," Kurzweil says. "We don't need all those calories. I have a low fat percentage, but I have to do that by controlling my eating.

Ultimately we'll separate that. We've actually identified the gene that does that."

Is that the marker of transcendence? When we can eat all we want and never be fat? "That's going to be one step, among many," Kurzweil replies. "When we do that, it will be considered a conservative, sensible thing to do. After you have done hundreds and thousands of those changes, we will be very different than we are today."

At a conference at Boston University, I once was told that we'll know we have transcended when The Enhanced start having difficulty telling the difference between Naturals and dogs. We will have evolved so far that all those carbon-based life forms will tend to blur. Is that what Kurzweil is talking about?

"Okay, the MOSHs," Kurzweil replies. "The Mostly Original Substrate Humans. Well, I think enhanced humans will become greatly enhanced compared to MOSHs. But I think there will be a continued respect for human life. I think that is built into our species. That is not necessarily an ultimately moral position. It's a species-centric position. That one is deeply rooted in our nature."

Really? I ask. What about our predecessor species? I don't see any Cro-Magnons or Neanderthals left—with the possible exception of a couple of editors.

"My view is that there will be respect for our species and where we have come from. It will take an absolutely trivial portion of the intellectual output of enhanced humanity to meet all of the material and other needs of the rest of humanity. So from the perspective of unenhanced humans, these new nonbiological entities will appear to be their transcended servants. But from the perspective of nonbiological intelligence, they are devoting a very trivial portion of their intellectual output to providing that service."

Do you believe in a God you plan on meeting when you die? I ask.

"I'm not planning to die," Kurzweil responds. "I expect to use the power of ideas. I am a survivor as an entrepreneur and a human being. It's my plan to be involved in this next phase of humanity where we get past some of the frailties of these Version 1.0 bodies we have. The way to 'meet our maker,' so to speak, is, in fact, by staying alive. We will be part of this very rapid explosion of intelligence, and beauty, and a very rapid acceleration of this evolutionary process. And that, to me, is what God is. Evolution, I think, is a spiritual process because it moves closer to what we have considered God. It moves closer to infinity."

I am nonplussed by this answer. He is not talking about us [illegible] meeting God.

He is talking about us *becoming* God.

Aware of how this sounds, he rephrases a little. "I don't think we actually ever become God. But we do become more God-like," he clarifies.

He then barrels right back to a grand view of The Heaven Scenario. "I see it, ultimately, as an awakening of the whole universe. I think the whole universe right now is basically made up of dumb matter and energy and I think it will wake up. But if it becomes transformed into this sublimely intelligent matter and energy, I hope to be a part of that."

He is talking about participating in the creation of Heaven.

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The Heaven Scenario

Ray Kurzweil and others in his camp do not consider their description of the future a scenario. They consider it a prediction. That is, they do not see the future they describe as one logical possibility among several for which it would be prudent to prepare, as is the case in scenario planning. They see the logic of their position as patently inescapable and their version of the future as inevitable. They frequently argue against the possibility that the other two scenarios described in this volume might ever occur. Nonetheless, since others disagree, and those with different versions of the future frequently end up debating each other, the vision of the future that in this volume is called Heaven, in which The Curve is inevitable and the outcome good, is treated here as a scenario.

Predetermined elements:

There are Curves of exponential change governing technology.

Critical uncertainties:

Are The Curves of exponential change accelerating smoothly? If so, how fast? Or are they displaying unexpected slowdowns, stops or reversals?

Are The Curves of change leading to progress, disaster or both?

Embedded assumption:

Technology drives history.

Early warning signs that we are entering The Heaven Scenario:

Almost unimaginably good things are happening, including the conquering of disease and poverty, but also an increase in beauty, wisdom, love, truth and peace.

Predictions that recently seemed like science fiction are routinely exceeded.

Even in the face of such wonders, humans are more or less spectators. Technology seems in control.

The phrase "The Singularity" enters common usage, as did the phrase "global warming" at the turn of the 21st century.

Early warnings that we are not entering The Heaven Scenario:

The growth of complexity slows or starts proving erratic.

Almost unimaginably bad things start happening. (This would be an early warning that we are entering The Hell Scenario.)

Culture and values gain control of technology such that events that once seemed inevitable are now consciously being avoided over significant periods of time, and by everyone on the planet. (This would be an early warning that we are entering The Prevail Scenario.)