Posthumanity: Changing Our Species

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Geneticist Lee Silver imagines a world where the human species has changed in such a significant way that the changes are on par with eons of evolution, but with one very different aspect: they are brought on by technology, not nature. His future scenario entails humanity eventually breaking apart into separate genRich and genNatural species, so vastly different in genetic makeup through years of genetic modifications that the two species cannot reproduce with each other. Silver makes these guesses based on his education and beliefs about human nature. His education tells him the science is possible, and his beliefs about human nature tell him the use of the science is inevitable. This paper examines other futurists; scientists with enough knowledge in their fields to make predictions worth thinking about.

Predictions about the future come in sundry flavors. We will be concerned only with those that hint at technology changing the way humans live. Francis Fukuyama is a professor at Johns Hopkins University who, like Silver, sees a future changed beyond recognition due to reprogenetic technology. Fukuyama believes that humanity itself will be altered through genetic engineering and designer babies. Andy Clark, the director of the Cognitive Science Program at Indiana University, sees humans and technology blending together to become one. His visions include implants that enhance not only our physical abilities but also our communication. Rodney Brooks, a professor of computer science and engineering at the Massachusetts Institute of Technology, predicts a future filled with conscious robots. After a brief time span in which robots will take over our manual labor, Brooks believes they will eventually evolve into beings that are alive in the special sense and will take roles in society as lovers and companions. Bill McKibbin is a scholar at Middlebury College who fears that reprogenetic technology, advanced robotics, and nanotechnology will cause human life to drift into meaninglessness. Unless these technologies are forced out of active research projects immediately, he says, they will end life as we know it. Finally, Ray Kurzweil paints a picture of a very near future in which machines meet human intelligence and eventually exceed us. Kurzweil also speculates that advanced medicine and robotics will cause human mortality to be a thing of the past.

Each futurist has his own ideas about which technological changes will make the biggest impact on our future, but there is some overlap. Both Kurzweil and Brooks believe that machines will surpass human intelligence, for example. Although each person's ideas can be looked at and understood separately, in this paper an effort will be made to discuss futurists with similar ideas one after the other. To begin with, we will discuss Francis Fukuyama, whose ideas on the future depend on those technologies discussed in Remaking Eden.

Francis Fukuyama thinks that the current biotechnology revolution will have ramifications much larger than just altering individuals. Politics and society are on the verge of changing as a direct result of reprogenetics. Before discussing his predictions, a brief explanation of genetic engineering is in order.

As an alternative to letting natural evolution and random chance decide everything about the offspring of a living organism, genetic engineering allows us to specify what qualities we want represented in the new offspring – and all of the offspring's subsequent descendants. A popular example of genetic engineering can be found in agricultural biotechnology: Bt corn. Novartis Seeds inserted a foreign gene into the DNA of normal corn. This gene causes the corn to produce a protein that is toxic to certain insects. Bt corn thus creates its own pesticide and passes the pesticide property to all of the corn's offspring. The result of this genetic engineering is insect-free corn for farmers. The concept is simple: modify an organism in a way that benefits society. As with any technology with seemingly obvious consequences, a variety of other side effects or entirely divergent futures may apply. For example, Bt corn is effective at killing various pests but is also found to be toxic to Monarch butterflies. On top of that, widespread use of Bt corn is spreading antibiotic-resistant genes, which could eventually render certain antibiotics useless. It is important to understand that the technologies that each futurist discusses may actually alter our lives in a vastly different way than predicted.

Applying genetic engineering to humans is the next step. There are two categories of genetic engineering: techniques that modify a single individual and are not passed on to future generations, and techniques that are implanted into one organism during initial cell division that are subsequently passed down to every descendant. The former technique is often referred to as somatic gene therapy. The latter is what we will discuss, because we do not care about individual ramifications but future nationwide and worldwide consequences. Two potential techniques available are germ-line engineering and artificial chromosomes. Both would allow custom-made human beings to pass their genetic modifications on to their offspring.

Fukuyama warns that while the Food and Drug Administration attempts to prevent harm to citizens by careful control of drugs, it often lacks long-term studies for drug usage. In the case of genetic engineering, when multiple genes may affect a characteristic of someone's personality or a single gene may affect multiple characteristics, it will be exponentially harder to figure out what the long term effects might be of altering a gene. What appears beneficial may in fact be significantly harmful as the organism ages.

In spite of this concern, Fukuyama believes that advanced reprogenetic technology will lead to increased lifespan. Every person in history has realized their inevitable end, yet the concept of immortality has been around since life itself. Gods are immortal. Mythic heroes often escaped death. It seems as if humans have had the dream of avoiding death since the beginning of time. For this discussion it does not matter whether people become virtually immortal, or if human lives are simply extended into the hundreds of years. How might increased or infinite prolongation of individual life affect societies?

With increased lifespan comes an increase of the median age in a given population. Currently, the median age in the United States is thirty-six, while the average life expectancy is seventy-seven (Fukuyama 61). Let us suppose that medical science and genetic engineering raises the life expectancy to something around the order of 177 years of age, a relatively modest increase of 100 years. Eventually, the median age would rise as well. Fukuyama argues that political and social change would occur more slowly because change is usually pushed by young generations who are sick of the 'old way of doing things.' In democratic societies, the voting power of the young would be substantially reduced because multiple generations of 'old-timers' would tip the balance of voting power in way unfavorable to young people. If Fukuyama is right that young people are the movers and changers of the world, then he would be correct in surmising that social change would occur more slowly.

Fukuyama asserts that elderly women will "emerge as one of the most important blocs of voters courted by twenty-first century politicians" in democratic and highly-developed first-world countries (Fukuyama 62). Women live statistically longer lives than men already, and their increased participation in politics could make them an important demographic to politicians of the future. It is reasonable to assume that under-developed countries will have last-access or no-access to the reprogenetic technologies that result in extended life spans. Thus, international relations will become a whole new animal, nearly unrecognizable from what it is today. America and other first-world countries will be increasingly guided in foreign relations policies by people much older than those in less developed countries. Assuming that first-world countries maintain the superpower status of today, countries like America would have a drastic change in foreign policy decisions. Fukuyama argues that women are statistically less supportive than men in regard to war, defense spending, and the use of force abroad (Fukuyama 62). Because an older public, including the aforementioned important older women could become an important factor in policy decisions, America could potentially reduce its aggressive international front and concentrate energy on more domestic politics.

Aside from international relations, various age-based social hierarchies would be destroyed or altered in an unrecognizable way. Whereas the oldest generation typically gets out of the way for top positions, a future with extended life spans could see multiple generations existing in the job market simultaneously.

If medical science allows older people to maintain their youthful bodies and mental capacities in parallel with their longer life spans, a host of problems could arise, especially for the young. Today, older people typically lose the ability to work, lack the new skill sets required for useful work, or retire at a societal-set age. This loss of workers makes room for young people to join the work force, become contributors to society, and begin earning an income. If people could work well past the current retirement age of 65, and instead worked until they were 100, 130, or 150, young people would be significantly disadvantaged compared to young people of today. Jobs where cutting-edge skill sets are not required, such as manual labor, would be nearly impossible to get because a worker with 90 years of experience constructing buildings would always be seen as a more valuable asset than a 20-year old who needs to feed himself. In a market where no professional skills are required so the cost of labor stays at a minimum, experienced older workers will out-compete younger workers for jobs.

In contrast, if genetic engineering allows people to become older but the medical science to keep them from deteriorating does not advance as quickly we could have a society where the average person requires nursing-home quality care. Current society typically cares for their elderly people when they are no longer capable of being independent. The burden this would leave on the younger populations, to pay for and look after their parents, could give young people a sense of enslavement to their responsibility of caretaking. Similar problems are cropping up today due to medically enhanced longevity. People are already living into their 70s and 80s, causing new social problems that need to be solved. Social security was devised at a time when the average person did not reach the age of 65 and thus would never collect. Now most people are alive to reap the benefits of social security and this is putting a strain on the younger working population.

Fukuyama's future is made possible by the same technologies (reprogenetics) Silver talked about. Let's visit other futurists with visions made possible through other advancements. Andy Clark believes that "human beings are *natural-born* cyborgs[i]" (Clark 3). Ever since we began clothing ourselves to retain heat, utilizing wrist-watches to maintain a constant perception of time, or wearing glasses to enhance vision, we have been cyborgs. Any time we enhance ourselves through the use of tools or technology, rudimentary or not, we are giving ourselves an easier existence or a better chance of survival. With new technology becoming smaller and smarter, Clark sees a future in which implants change the way humans live and interact. He argues that our bodies and minds are good at some activities and simply not created for others, but implants can compliment humans and raise the level of our abilities.

> The squishy matter [of a brain] is great at some things. It is expert at recognizing patterns, at perception, and at controlling physical actions, but it is not so well designed for complex planning and long, intricate derivations of consequences. It is, to put it bluntly, bad at logic and good at Frisbee. (Clark 5)

Clark believes that human minds are "tailor-made for multiple mergers and coalitions" (Clark 7). The future that Clark paints is one in which advanced technology is implanted directly into our bodies. Cochlear implants are a good model for thinking about how additions to our bodies could help human beings. Cochlear implants are used by deaf people to allow them to hear again by electronically stimulating the auditory nerve. Clark insists that these implants do not make the user any less human, because we have always been using tools to aid us in one way or another. Implants could monitor vital signs such as breathing and heart rate, and upload data wirelessly to our healthcare providers. If trouble is detected, the implant could "automatically call for help" (Clark 27). Problem detection aside, implants will (and already do) have the ability to actually improve the health of a patient. Pacemakers have been electronically regulating the heartbeat of people with high risk of heart attack for years already. Defibrillators are now being combined with pacemakers to provide immediate shock therapy to hearts undergoing dangerous arrhythmia (irregular heartbeats). It is when the cybernetic implants become enhancements rather than fixes that Clark's predictions get exciting.

It is important to first explain the plasticity of our minds before enumerating various implants that our bodies may interact with. The plasticity of the brain is the property that allows it to work with and adapt to new pieces of anatomy naturally. Clark demonstrates the ability of our minds to adapt through an easy experiment:

> Sitting at your desk, place your left hand underneath the desktop. Get a volunteer to tap the desktop with her right hand while using the left to (in synchrony) tap your hidden hand. Many subjects will feel as if the "being tapped sensation" is located on the desk surface – as if the desktop were a real, sensitive part of their body. Now have the

> volunteer hit the desktop with a hammer. Your galvanic skin response jumps as if your own hand had been threatened. (Clark 60)

Not only will our minds fully accept implants as *part of us*, they will also interact with them as if they were native to our bodies. A third hand was implanted onto a man and was controlled by EMG signals detected by electrodes placed on four strategic muscle sites on his legs and abdomen (Clark 115). After many years of use, the user reported that he was "able to operate the third hand intuitively and immediately, without effort and not needing to consciously focus" (Clark 116). Much like learning to drive a manual transmission car begins as a task of high focus and concentration but ends up being "second nature," implants to our bodies can become as easy to operate as the limbs we are born with. Clark calls this the *transparency* of technology: when its use becomes obvious and functional on a level that requires no thinking about how or why the technology works.

A computer cursor can be moved mentally, as demonstrated by a paralyzed stroke victim who had two neural implants inserted into his motor cortex (Clark 121). Although the patient initially had no instruction or idea how to get the cursor to move, (imagine having a new leg you've never used before, but isn't paralyzed), eventually the activity of moving the cursor becomes as simple as raising your arm while requiring the same level of *mental work* as willing your arm to rise. Our minds can accept new pieces of equipment and learn to use them. Clark elucidates this fact using a thought experiment:

> Imagine you are an infant, above whose crib dangles an attractive mobile. You want to touch it, but you do not yet know how to issue the correct motor commands to do so. Your brain, however, generates many bursts of essentially random neural activity. Some of these bursts seem to move your hand closer to the target. After a while, you learn how to generate this kind of neural activity at will, and hence how to control your own limbs so as to carry out your project. (Clark 123)

What implants will be powerful enough to impact our lives, then? Clark gives many examples. A Remembrance Agent would be a proactive memory aid. By taking in information visually and aurally, a probe would search through previous notes taken using the system and display them on your retina for viewing:

> When she later gets out of class and runs into a fellow student, the identity of the student is either entered explicitly or conveyed through an active badge system or automatic face recognition. The RA starts to bring up suggestions pointing to notes entered while around this person, including an idea for a project proposal that both students were working on. (Clark 47)

While global positioning systems (GPS) have been around for a decade, they are currently not part of the user but rather a separate machine. By combining GPS with retinal implants or special glasses, something much more powerful could result:

> To find the library, you simply enter the name "library" in a handheld local guide-box and don a pair of special eyeglasses. As you look around, you see a giant green arrow take shape in the sky, pointing at the roof of the library. Looking down at the path, you see smaller arrows indicating the best route. Hanging in the air around your body you notice a variety of small icons offering you other local services. To use them, you just reach out and "touch" them, sending position and motion information through sensors in your clothing. (Clark, 52)

This technology could help people drive, fly planes, and find their way home. Lifeguards could have giant arrows pointing at the location under the water of where a person was drowning. This example of augmented reality would clearly have military applications as well. Soldiers could have ever-present information regarding the location of enemies, allies, and objectives in their line of sight, perhaps 50% transparent so as not to block their view during dangerous missions.

By implanting a radio transmitter and receiver directly into our vocal chords and cochlear implants (with some ability to turn this on and off and send at a desired frequency), the resulting ability would be synonymous with having telepathy. The age of cell phones has already changed the way we communicate, but always-ready voice communication would bring our species to the next level of interconnectedness.

The advanced electronics of the future do not necessarily have to be implanted into a human, however. Our next futurist sees a world in which beings are entirely manufactured. Rodney Brooks is the author of several books and is the chairman and chief technological officer of iRobot Corporation. Brooks is also a founding fellow of the American Association for Artificial Intelligence and a fellow of the American Association for the Advancement of Science. He is the director of the Artificial Intelligence Laboratory at MIT. Brooks (and Kurzweil, as we shall see) believe that humans are *wetware* organic machines that can be duplicated with metal and silicon. The "specialness" that we attribute only to beings with consciousness will eventually include these robots, and human specialness will be diminished. What happens when robots become 'conscious'?

Many fears about computer consciousness stem from Hollywood movies where the machines, built by humans, evolve to be smarter than intended and deem their creators unnecessary. In *The Terminator* a network of robots called Skynet plans to wipe out the human race. *The Matrix* portrays a future in which human-created artificial intelligence reproduces on its own and enslaves humanity for energy production. This fear is more ingrained in public awareness than the actual science behind artificial life. After Stanley Kubrick's *2001: A Space Odyssey* portrayed a computer (the infamous HAL 9000) killing human beings in order to carry out a human-initiated mission, technological damnation has been a public fear. One top marketing executive at IBM was fired in the early 80's for labeling its latest computer system as 'smart' instead of 'powerful' or 'speedy' (HAL's Legacy, 1997). Brooks denies the possibility of machines ever taking over as the authority to humans by stating four conditions that must take place before machines gain control.

1. The machines can repair and reproduce themselves without human help.
2. It is possible to build machines that are intelligent but which do not have human emotions and, in particular, have no empathy for humans.
3. The machines we build will have a desire to survive and to control their environment to ensure their survival.
4. We, ultimately, will not be able to control our machines when they make a decision. (Brooks 200)

None of these requirements are likely to take place in the next twenty-five years, Brooks believes. In order for a machine to reproduce, robots would need to reproduce their CPUs. Currently, CPUs are built in fabrication facilities that cost well over $1 billion, and are some of the most highly automated facilities on Earth – yet they still have thousands of people working in the plant. Building emotionless robots that operate in the world intelligently requires the programmer to "encode every fact about the world directly for them" (Brooks 201). Emotion helps human beings shape the rational decision making processes, so a machine without emotions would need to have every answer to every problem hard-coded at the time of production. This is impossible. Survival instinct *can* be coded into a robot, but Brooks believes we are "decades off from (producing) robots that can metabolize any other source of energy (other than electricity) in a way that will let them live off the land and get away from our control of their energy sources" (Brooks 202). Finally, to lose control Brooks believes we would have to "build machines that could deliberately outsmart us" (Brooks 202). Before we have machines over which we have no control we would have to create machines over which we occasionally lose control, and then machines over which we have little control. Scientists would have to deliberately not include fail-safes for us to not have the final decision on robotic action. (Brooks 203). What Brooks overlooks is the potential for machines that do not require human control crossing into a new domain. While we may give incredible or superior intelligence to a machine that does one harmless job, what is to prevent the machine from eventually evolving to do something else that might be dangerous?

Not agreeing with damnation does not mean Brooks sees salvation for the human race through robotics, either. Some scientists believe consciousness will be able to be uploaded onto a computer or robot and thus live on forever. To do this, the machinery of our brains would need to be taken apart "piece by piece, and simulating it in a computation" (Brooks 206). After this ludicrously difficult-to-imagine process was completed, we would have a virtual version of our brain running on a computer (Brooks 206).

> This strong version of salvation seems plausible in principle. However, we may yet be hundreds of years off in figuring out just how to do it. It neglects the primary role played by the bath of neurotransmitters

> and hormones in which our neuronal cells swim. It neglects the role of our body in placing constraints and providing noncomputational aspects to our existence. (Brooks 206)

Although Brooks doesn't believe we will be able to upload our consciousness to a computer, he does see computers that are as alive as humans: conscious beings that do not mimic emotions, but rather have the same high-level understanding of the world that evokes similar emotional responses as humans do. When this happens, we will give rights to the machines in the same way that slaves were given rights once they were seen as human.

Aside from robots that resemble humans in size and character, another futurist believes much smaller robots could impact our world. Bill McKibbin is petrified that advances in nanotechnology will end life as we know it (McKibbin, 71). "Nanotechnology is the application of nanostructures into useful nanoscale devices" (Ratner, 7). Nano is a prefix that means "one billionth." A nanometer is thus 1/1,000,000,000 of a meter. A human hair measures 50,000 nanometers across (Ratner 7). Nanotechnology is fascinating because its promise is to create machines that do complex work at molecular levels. To add to the mystery of what is possible, nano-size devices do not follow the same laws of physics as devices at current sizes. "At the nanoscale, the most fundamental properties of materials and machines depend on their size in a way they don't at any other scale. For example, a nanoscale wire or circuit component does not necessarily obey Ohm's law, the venerable equation that is the foundation of modern electronics" (Ratner 7).

According to Bill McKibbin, the holy grail of nanoscientists is an *assembler.* Roughly the size of a strand of DNA, an assembler would be a machine able to move individual atoms around and put them precisely where you wanted them (McKibbin 80). The power of such a device would be nothing short of magical in most people's eyes.

> With a programmable assembler, one that could move billions of atoms to the right place at the right time so they would stick together in molecular structures according to the laws of chemistry – well then, you really would be able to build anything. Working at a million atoms per second, an assembler would be able to copy itself in a thousand

> seconds – about fifteen minutes, or the time a bacterium takes to replicate. And then each of those assemblers could build a copy of itself. In ten hours the assemblers could replicate 68 billion times. (McKibbin 81)

What would an assembler be good for, then? They could "solve humanity's material needs" (McKibbin 81). With a universal assembling machine you could place some weeds in one end, and after the assembler seized the carbon in the weeds and broke down chemical bonds to construct others, you could pull out a "wad of fresh beef" (McKibbin 81). Why is McKibbin so scared, then? He is afraid that nanotechnology threatens our way of life. Nanoweapons designed to destroy biological organisms could be created. "Bad as atom bombs were, you had to build them one at a time" (McKibbin 90). A single self-replicating nano-replicator could eat up everything in its path and turn the entire surface of the earth into alternative materials. Nothing could live in a biosystem where all of the carbon had been extracted to create synthetic materials or more nano-assemblers.

What would prevent self-replicating assemblers from multiplying endlessly and turning the world into a gray goo of altered matter? The biggest hurdle would be access to raw materials. Bacteria and even humans use up resources and reproduce but have yet to destroy every other living thing in our path. As the resources are used up in a given location, the environment can change into one inhibitory for further growth. Any entity that desires to reproduce has a whole host of other problems to solve. Where would the waste products from reproduction and general existence go? How would the assemblers travel far distances to reach more usable resources? Finally, how would these tiny nanobots protect themselves from predators? While we could devise nano-police-bots to combat or fight malignant bots, a basic flamethrower would wipe out trillions of these nanobots with a few pennies worth of gasoline.

Ray Kurzweil takes Moore's Law[ii] to the extreme. By the year 2020, Kurzweil believes that $1,000 will buy a computer that calculates at the speed of a human brain. Even more shocking, by 2060 that same $1,000 will buy a computer that calculates at the speed of all human brains collectively (Kurzweil 104). This will have remarkable impacts on human life, with the most important developments in the medical field. Increased computing power will give rise to nanotechnology. Nanobots will be able to keep people forever young. They will swarm throughout the body repairing anything showing signs of age or malfunction: bones, muscles, arteries and brain cells. Kurzweil even imagines that improvements to our genetic coding will be "downloaded via the Internet" (CNN).

Keurzweil predicts that by 2029, computers will interact directly with the human brain via "high bandwidth neural pathways" (Kurzweil 220). Like Clark, Kurzweil believes that high-technology implants will be commonplace. Images will be "projected directly onto the retina providing the usual high-resolution three-dimensional overlay on the physical world" (Kurzweil 220) similar to Clark's augmented reality.

Education will change as well. When computers are fast enough, they will be able to read all available human and machine-generated literature, and create "significant new knowledge" with little or no human intervention. By 2029, learning and studying will still be the "primary focus of the human species" (Kurzweil 221), but not for long. Eventually, humans will be able to download knowledge directly into their data structures of the human mind, eerily similar to Neo mastering Kung Fu in 30 seconds (in The Matrix).

Machines will have personalities and skills like humans, and humans will have implants that provide them with enhanced perceptual and cognitive functioning like machines (Kurzweil 222). Most business interactions will in fact be between a human and a virtual persona, tailored to suit your individual preferences and habits. Think Amazon.com's recommendations placed into a humanlike persona, always available to help you decide what you need.

There are opponents to the idea that Moore's Law will continue, some saying that the speed of light provides us with a maximum limit to the rate at which information can flow. Kurzweil and others get around this limitation by introducing parallel computing (quantum computing) and miniaturization past the microscopic level. Regardless of where computational growth ends up, it is certainly no where near its end now.

Short-term speculations regarding reprogenetic advancement are useful, but increasingly important is thinking about the long-term effects of our biotechnology. When longer life spans can lead to a shift in political focus from foreign relations to domestic concerns, we can see that more than just our children's piano abilities are at stake. If we break apart from a single species, our current hopes and fears will become complicated with an additional layer of abstraction. Will humanoid descendants wage war against one another, attempting genocide of their "parent" species? Most importantly, does any amount of preparing or planning guarantee or even hope to alter the inevitable changes coming for the human species?

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[i] Cyborg: A human who has certain physiological processes aided or controlled by mechanical or electronic devices.
[ii] Moore's Law: A tendancy for computing power to double every 18 months.

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